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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 570 001 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 93107882.8

(51) Int. Cl.5: G09G 3/36

(22) Date of filing: 14.05.93

(30) Priority: 14.05.92 JP 121574/92
21.05.92 JP 128554/92
12.10.92 JP 272733/92

(43) Date of publication of application:
18.11.93 Bulletin 93/46

(84) Designated Contracting States:
DE FR GB

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(54) Liquid crystal display device.

(57) A wiring 19 of a device directly detects a voltage from a plurality of scanning electrodes 1, a voltage detecting electrode 701 detects a voltage from a plurality of the scanning electrodes 1. A voltage variation component such as voltage distortion of the detected voltage which adversely affects on an image display is taken out, inverted, and negative fed back to the scanning electrode 1. A negative feedback loop provides the negative feedback of the voltage detected from and fed back to the scanning electrode 1, this therefore suppresses the disadvantageous voltage variation such as a distortion voltage which tends to arise in the scanning electrode 1.

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FIGs. 39(a) and 39(b) are an equivalent representations showing one scanning electrode partially extracted from the conventional XY simple-matrix type liquid crystal display device. A scanning electrode (Y_n) 3901 and a signal electrode (X_n) 3903 are arranged as intersected and opposed with each other, and a liquid crystal layer 3905 is held between the counter electrodes 3901 and 3903. An electrode resistance (R) 3907 in FIG. 39(b) is a total sum of electric resistances of entire drive circuit systems; namely, an internal output resistance (R') 3911 of the scanning electrode driver circuit 3909 connected to the scanning electrode 3901 and for applying voltage thereto; a connection resistance between the scanning electrode driver circuit 3909 and the scanning electrode 3901; and a electrode resistance which the scanning electrode 3901 itself has. C_{LC} is a static capacitance of the liquid crystal layer 3905.

A power supply (V0) 3913 for generating voltage (scanning signal) applied to the scanning electrode 3901 is connected to the scanning electrode 3901, a power supply (V1) for generating voltage (data signal) applied to the signal electrode 3903 is connected to the signal electrode 3903 at a connecting point P1 through a switching means. A scanning signal V0 is named as 0V for simplifying the explanation.

The liquid crystal display element is normally promoted of its deterioration when applied direct-current component voltage, thus it is driven by a square wave voltage similar to an alternating-current. For this reason, the data signal V1 is assumed to output voltage V1 with polarization inverted as centered on 0V in FIG. 39(C). In consideration that such square waveform data signal V1 is applied to the signal electrode from the signal electrode driver 3915 side, a spike voltage distortion V2 due to a time constant $C_{LC} \cdot R$ is generated at a connecting point P2 across C_{LC} formed by the liquid crystal layer 3905 and an electric resistance R of the driving circuit system. This distortion voltage V2 is shown by a waveform graph in FIG. 39(d). Thus generated distortion voltage V2 provides V2-V1 made from liquid crystal applying voltage VLC applied to the liquid crystal layer 3905 and the waveform being cut off by the amount corresponding to the spike voltage distortion V2 in FIG. 39(e). The liquid crystal applying voltage VLC applied to the liquid crystal layer 3905 is varied of its effective voltage due to the distortion of drive voltage waveform (voltage V2) generated in voltage at the scanning electrode side. Such variation of effective voltage is still varied with phase difference of the square wave applied to the signal electrode 3903. Depending on the display image there exist a pixel having voltage variation to be increased and a pixel having voltage variation to be decreased, these are seen as fluctuation of transmittance of light on display picture of the liquid crystal display element. This describes an irregularity on display called as a crosstalk.

The explanation in more detail is provided as under-mentioned for crosstalk generation due to the driving voltage waveform distortion in the simple-matrix type liquid crystal display device as shown in FIGs. 35 to 37.

FIGs. 40(a) and 40(b) are views of the data signal waveform and the scanning signal waveform (non-selected period) applied to the liquid crystal layer corresponding to the region (a) and the region (b) in FIG. 35. A spike shaped distortion voltage in synchronization with the data signal waveform is generated on the scanning signal waveform of the non-selected period . This is because the scanning electrode receives induction from the data signal waveform through the static capacitance formed by the liquid crystal layer and to vary an potential of the scanning electrode. As a result, the liquid crystal applying voltage of the region (a) (that is, the waveform overlapped of the data signal waveform and the scanning signal waveform) is decreased by the voltage corresponding to the distortion as shown by oblique lines in FIG. 40(a). On the other hand, decrease of the liquid crystal applying voltage of the region (b) hardly arises substantially as shown by oblique lines in FIG. 40(b).

Therefore, the liquid crystal applying voltage (b) of the region (a) becomes smaller comparing to that of the region (b), thereby a dark crosstalk is generated.

FIGs. 41(c) and 41(d) show a data signal waveform and a scanning non-selected voltage waveform corresponding to the region (c) and (d) in FIG. 36 (or the region (h), region (f) in FIG. 37 respectively). Fig. G shows wavefrom variation before and after polarization inversion. Solid lines in FIG. 41 designate the display pattern 3507 of vertical line shape in FIG. 36, dotted lines designate the display pattern 3513 of block shape in FIG. 37. A distortion voltage is generated on the scanning signal waveform at the time of inverting a polarity, and differs depending on the display pattern, in FIG. 41. This arises because the polarity of the induction potential differs at every display pattern when a potential of the scanning electrode is varied by receiving induction from the data signal waveform through the static capacitance of liquid crystal at the time of inverting polarity.

Consequently, in vertical line shaped display pattern in FIG. 36, a liquid crystal applying voltage of the region (c) is increased by the amount corresponding to a distortion voltage shown in oblique line portion of FIG. 41(c). On the other hand, the liquid crystal applying voltage of the region (d) is decreased by the amount corresponding to the distortion voltage shown by the oblique line portion of FIG. 41(d). Accordingly, the liquid crystal applying voltage of the region (c) becomes larger compared to that of the region (d)

Even when the voltage fed back to the scanning driver circuit is amplified to a level in an extent of distortion voltage to be a cause of the crosstalk, because the voltage to be fed back (feedback voltage) is obtained only from one output of the scanning driver circuit, largeness of the voltage distortion of the output other than such obtained one output is not reflected, thus it is actually not possible to carry out sufficiently effective reduction of the voltage distortion for all the scanning electrodes. The reason is that a largeness of the output voltage distortion exhibits different sizes at every scanning electrode.

In this method, the actual effective reduction of the drive waveform distortion of the scanning electrode of the liquid crystal display element is extremely difficult because the scanning electrode itself of the liquid crystal display element is not included in the feedback loop (feedback system). It is desirous for reducing the crosstalk that an effect of the distortion reduction is obtained as uniformly as possible over the entire liquid crystal display element, needless to say, in addition to reduction of the drive waveform distortion of the scanning electrode of the liquid crystal display element.

Another method of reducing the scanning drive waveform distortion includes a method disclosed in SID, 1990 Digest, p.412 to p.415. This method of driving is that the control voltage (complimentary voltage) of a voltage level based on the ON or OFF dot number counted from the display data is generated, and applied to the scanning power supply section for supplying voltage to the scanning driver circuit to synthesize with the scanning non-selected voltage and to cancel voltage fluctuation due to the distortion voltage each other.

However, this method intends to cancel dull phenomenon or distortion of voltage of the scanning electrode each other using a fine voltage level previously set corresponding to the dot number of ON and OFF of the display data (image data). Thus, for example, in the device for varying contrast by changing the liquid crystal drive voltage or for performing a gradation representation, the largeness of the voltage distortion is varied with change of the liquid crystal drive voltage, an optimum correction becomes difficult because the optimum correction voltage value is shifted from a correction voltage previously set as a correction value at the initial time for canceling the voltage distortion and the like. This control system therefore requires addition of a readjustment circuit and the like for automatically resetting an optimum correction voltage at every time required. An incorporation of such circuit having a readjustment circuit and for setting fine voltage depending on the display data causes another disadvantage in considerably complicated construction of the liquid crystal drive circuit system. The same readjustment circuit is also desired for adjusting variation of a response characteristic due to aged change of the liquid crystal layer or variation of temperature condition and the like.

Another method for reducing the scanning drive waveform distortion is disclosed in Eurodisplay 1984, Digest p.15 to p.20. This method of driving is basically similar to the control system as immediately previously described, but a different point resides in the control voltage (complimentary voltage) which is taken out from a voltage of the signal electrode. A variation of the voltage applied on the signal electrode is detected by obtaining a mean value of voltages of all the signal electrodes. Such method is resultantly similar to the method of counting the number of ON dot or OFF dot.

This method is that a control voltage previously set based on the data signal which is a cause of varying the voltage of the scanning electrode is formed and this control voltage is applied to the scanning signal power supply to synthesize to the scanning electrode waveform. Thus, an optimum correction is not always performed for dull phenomenon or distortion itself of the voltage of the scanning electrode, rather the optimum correction is shifted due to change of the temperature condition or aged change and the like of the liquid crystal layer, the correction voltage (control voltage) is readjusted at every time required. The largeness of the voltage distortion is varied depending on variation of the liquid crystal driving voltage even in changing contrast by varying the liquid crystal driving voltage or in performing gradation representation, the optimum correction voltage is required to be reset at every time required. Additional readjustment circuits and the like are required. An incorporation of the circuit having such adjustment circuits and performing setting of the fine voltage based on the data signal disadvantageously produces a considerably complicated construction of the liquid crystal drive circuit system. The similar adjustment circuit is required for the aged change.

In another point of view of the driving method, an example of the method of driving for a simple-matrix type liquid crystal display device having a rapid response time includes the Active Addressing method, or the Multiple Line Selection Method disclosed in SID, in 1992, Digest, p.228 to p.231 and p.232 to p.235. In a voltage averaging method generally used, liquid crystal is applied a scanning signal of waveform formed of both a selected pulse of higher voltage in a very short time within one frame period and a non-selected voltage of a lower voltage of the period other than the selected pulse period. Contrast to this, in the previous method of driving is given of both a scanning waveform Fi (t) formed of an optional orthonormal set and a multi-valued signal waveform Gj (t), consequently the synthetic voltage waveform applied to the liquid crystal is distributed within a frame period. In case of using the liquid crystal display element having a

FIG. 8 is a view of a liquid crystal display device of the embodiment 4;
FIG. 9 is a view of a liquid crystal display device of the embodiment 4;
FIG. 10 is a view of a liquid crystal display device of the embodiment 4;
FIG. 11 is a view of a liquid crystal display device of an embodiment 5;
FIG. 12 is a view of a liquid crystal display device of an embodiment 6;
FIG. 13 is a view of a liquid crystal display device of an embodiment 7
FIG. 14 is a view of a liquid crystal display device of the embodiment 7;
FIG. 15 is a view of a liquid crystal display device of an embodiment 8;
FIG. 16 is a view of a liquid crystal display device of an embodiment 9;
FIG. 17 is a view of a liquid crystal display device of the embodiment 9;
FIG. 18 is a view of a liquid crystal display device of an embodiment 10;
FIG. 19 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 10;
FIG. 20 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 10;
FIG. 21 is a view of a liquid crystal display device of an embodiment 11;
FIG. 22 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 11;
FIG. 23 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 11;
FIG. 24 is a view of a driving voltage waveform of a liquid crystal display device of an embodiment 12;
FIG. 25 is a view of a liquid crystal display device of the embodiment 12;
FIG. 26 is a view of a liquid crystal display device of the embodiment 12;
FIG. 27 is a view of a liquid crystal display device of a comparison example for the embodiment 12;
FIG. 28 is a view of a liquid crystal display device of an embodiment 14;
FIG. 29 is a view of a liquid crystal display device of an embodiment 18;
FIG. 30 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 18;
FIG. 31 is a view of a liquid crystal display device of an embodiment 19;
FIG. 32 is a view of a liquid crystal display device of an embodiment 20;
FIG. 33 is a view of a driving voltage waveform of a liquid crystal display device of the embodiment 20;
FIG. 34 is a view of a liquid crystal display device of the embodiment 20;
FIG. 35 is a view of a crosstalk on a display image of the conventional liquid crystal display device;
FIG. 36 is a view of a crosstalk on a display image of the conventional liquid crystal display device;
FIG. 37 is a view of a crosstalk on a display image of the conventional liquid crystal display device;
FIG. 38 is a view of the conventional liquid crystal display device;
FIG. 39 is a typical view of one scanning electrode of the conventional liquid crystal display device;
FIG. 40 shows voltage variation such as voltage distortion produced in a liquid crystal applying voltage of the conventional liquid crystal display device;
FIG. 41 shows voltage variation such as voltage distortion produced in a liquid crystal applying voltage of the conventional liquid crystal display device; and
FIG. 42 shows voltage variation such as voltage distortion and dull waveform produced in a liquid crystal applying voltage of the conventional liquid crystal display device.

EMBODIMENT 1

FIG. 1 is a typical view of a liquid crystal display device of an embodiment 1 according to the invention. The liquid crystal display device includes liquid crystal display elements 7, and a scanning driver circuit 9 and a data driver circuit 11 both for driving the liquid crystal display elements 7. The liquid crystal display elements 7 have liquid crystal layers (liquid crystal composition) 5 held in a gap between a scanning electrode 1 formed of transparent conductive films such as ITO and a signal electrode 3 both arranged opposing to each other in a matrix shape. The liquid crystal display elements 7 is constructed in that, at each scanning electrode 1, a voltage of the scanning electrode 1 other than voltage of a voltage input terminal 13 is directly detected and connected to an input terminal 17 of an operational amplifier 15 provided within a scanning driver circuit 9, and thus the voltage of the scanning electrode is controllably negative fed back. Then, the operational amplifier 15 functions that the detected voltage from the scanning electrode 1 is negative fed back to the scanning electrode 1.

In the liquid crystal display device of the embodiment 1, the negative feedback of the voltage of the scanning electrode 1 provides cancellation of variation of distortions and the like even when any of distortion or dull phenomenon are generated in the voltage of the scanning electrode 1 due to receiving induction or external disturbance from voltage of the signal electrode. Thus, the crosstalk on the display image is eliminated.

to synthesize it with an output of the scanning driver circuit 9, to be fed back to the scanning electrode 1, and to cancel the distortion voltage. Thereby, the crosstalk of the display image is eliminated.

The liquid crystal display device of the embodiment 1 is driven to display the image, and its display quality is visually inspected. A liquid crystal driving voltage used for driving the liquid crystal display device has a waveform in FIG. 4 that is polarity inverted at every 13 line basis with a duty ratio of 1/64, a bias ratio of 1/10, and a frame frequency of 80 Hz.

In inspection, after an entire display is made white. a black and white horizontal strip pattern is displayed in a region of vertical 50 dots x horizontal 10 dots adjacent to a display center, continuously the number of dots at horizontal of the region is gradually increased up to 100 dots, then in any of cases a uniform display without crosstalk is maintained. The Chinese characters and alphabet are continuously displayed, then generation of the distortion voltage in the scanning electrode 1 is suppressed to maintain the uniform display without crosstalk.

COMPARISON EXAMPLE TO EMBODIMENT 1

The conventional construction of the liquid crystal display device, in which the wiring 19 for detecting the scanning electrode voltage from the scanning electrode 1 and the operational amplifier 15 inside the scanning driver circuit 9 are removed from the liquid crystal display device of the embodiment 1, has been driven under the same driving condition of the embodiment 1 to display the image.

First, an entire display is made white. Thereafter a black and white horizontal strip pattern is displayed in a region of vertical 50 dots x horizontal 10 dots adjacent to a display center, continuously the number of dots at horizontal of the region is gradually increased up to 100 dots. When the black and white horizontal strip pattern is displayed in the region of vertical 50 dots x horizontal 10 dots, a crosstalk darker than its periphery is generated on its vertical direction. The horizontal dot number of the display region is gradually increased, the crosstalk in vertical direction has been more remarkably generated. In addition, a new crosstalk is generated in horizontal direction of the horizontal strip pattern display, its display quality has been considerably deteriorated. When the Chinese characters and alphabet are continuously displayed, then the remarkable crosstalk chained to vertical and horizontal directions is generated to produce a conspicuous irregularity and to exceedingly lower the display quality.

EMBODIMENT 2

FIG. 5 is a typical view of a liquid crystal display device of an embodiment 2, where the same numerals as in FIGs. 1 to 4 are given to the same parts as those described in the embodiment 1.

A liquid crystal display device of this embodiment 2 is characterized in that the negative feedback loop of the embodiment 1 is applied to the signal electrode 3, and the negative feedback controllably cancels a voltage variation such as distortion voltage generated in a voltage of the signal electrode 3 induced by the scanning selected voltage (scanning pulse).

An operational amplifier 501 arranged inside the data driver circuit 11 functions that the voltage distortion component and dull component of the signal electrode 3 are detected to be negative fed back to the signal electrode 3 for eliminating the voltage distortion and dull phenomenon of the signal electrode 3. The input terminal 503 of the operational amplifier 501 is connected to each of a plurality of signal electrodes 3 arranged in plural rows at one-to-one connection basis by the wiring 505. In this operational amplifier 501, a voltage variation (for example, a signal delay and the like) produced in the signal electrode voltage by detecting each voltage of the connected signal electrodes 3, is inverted and fed back to the signal electrode 3 (that is, a negative feedback to the signal electrode 3).

Even when the liquid crystal display device is formed so as to incorporate the signal electrode 3 into a negative feedback loop using the operational amplifier 501 and a distortion voltage is induced in a voltage of the signal electrode 3, then induced distortion component of the signal electrode 3 is detected, to synthesize it with an output of the data driver circuit 11, to be negative fed back to the signal electrode 3, and to cancel the distortion voltage component of the signal electrode 3. Thereby, the crosstalk of the display image is eliminated.

The liquid crystal display device of the embodiment 2 is driven to display the image, and its display quality is visually inspected. A liquid crystal driving voltage for driving the liquid crystal display device has a waveform in FIG. 4 that is polarity inverted at every 13 line basis with a duty ratio of 1/128, a bias ratio of 1/10, and a frame frequency of 80 Hz.

In inspection, after an entire display is made white. a black and white horizontal strip pattern is displayed in a region of vertical 100 dots x horizontal 10 dots adjacent to a display center, continuously the

by a voltage dividing circuit 625 provided inside the driving voltage supply circuit 623 to produce potentials of Von, Voff, and Vcom respectively. Since liquid crystal is promoted its deterioration by being applied direct-current voltage and generally required to be driven by alternate-current voltage, then potentials Von, Voff and Vcom are polarity inverted periodically.

In FIG. 6 there is used an operational amplifier 631 in which the voltage distortion component and dull component of the counter electrode 611 are detected to be negative fed back to the counter electrode 611 through wiring 627 and an input 629 provided on the driving voltage supply circuit 623 connected thereto for eliminating the distortion and dull phenomenon of the voltage of the counter electrode 611. The operational amplifier 631 for performing the negative feedback control is connected to the counter electrode 611 and inverts a voltage variation (that is, for example, the spike shaped distortion voltage and the like) generated in the voltage of the counter electrode 611 to negative feed back it to the counter electrode 611. The operational amplifier 631 in this embodiment 3 is simultaneously used as a buffer for applying the counter electrode voltage Vcom to the counter electrode 611.

Even when the liquid crystal display device is formed so as to incorporate the counter electrode 611 into a negative feedback loop formed of the operational amplifier 631 and a distortion voltage is induced in a voltage of the counter electrode 611, then induced distortion component is detected, to synthesize it with a voltage of the counter electrode 611 at the operational amplifier 631, to be negative fed back to the counter electrode 611, and then to cancel the distortion voltage of the counter electrode 611. Thereby, the crosstalk of the display image is eliminated.

Actually, the liquid crystal display device described above is driven to display using a H line inversion driving system for inverting and driving a polarity of the data signal waveform at every scanning selected period basis, a V line inversion driving system capable of inverting a polarity of the data signal waveform at every data line basis and inverting and driving it at every frame basis, and further a H common inversion driving system for inverting and driving the counter electrode voltage at every scanning basis. As a result of these, by any of those diving systems the distortion is effectively removed from the counter electrode voltage and a satisfactory display image has been realized without crosstalk.

In this embodiment 3, the wiring 627 detecting the counter electrode voltage is positioned substantially at a center of the counter electrode. However in the invention, such position is not limited to the center thereof, therefore, even when it is provided on an end of the counter electrode 611, the distortion of the counter electrode voltage is similarly effectively canceled by a negative feedback control.

COMPARISON EXAMPLE TO EMBODIMENT 3

The wiring 627 connected to the counter electrode 611 for detecting the counter electrode voltage is removed from the liquid crystal display device in the embodiment 3. The negative feedback control operation of the operational amplifier 631 is allowed to stop and used as an ordinary voltage follower, and to produce the active-matrix type liquid crystal display device having the conventional construction using a voltage follower formed of the conventional operational amplifier, which has been driven to display the image under the driving condition as in the embodiment 3.

As a result, a distortion voltage has been generated in the counter electrode to generate a crosstalk chained to horizontal direction, to produce a conspicuous irregularity of the display, and to considerably deteriorate a display quality. In particular, in case of being driven by the H line inversion driving system and the H common inversion driving system both capable of varying a polarity of the data signal at every scanning selected period basis, a large distortion voltage is generated in the counter electrode to considerably produce the crosstalk.

EMBODIMENT 4

FIG. 7 is a typical view of a liquid crystal display device of an embodiment 4, and FIG. 8 is essentials of a circuit construction thereof, where the same numerals are given for the same parts as those of the embodiments 1 to 3.

The liquid crystal display device includes a liquid crystal display element 7, a scanning driver circuit 9 and a signal circuit 11 for driving the liquid crystal display element 7, a voltage detecting electrode 701 for detecting voltage of a scanning electrode 1 provided on the liquid crystal display element 7, and an operational amplifier 703 for negative feeding back to the scanning electrode 1 a voltage detected by the voltage detecting electrode 701.

In the embodiment 1, a voltage of the scanning electrode 1 is detected from the wiring 19 directly connected to the scanning electrode 1, and negative fed back it to the scanning electrode 1. However, in

horizontal of the region is gradually increased up to 300 dots, as a result of these, any of cases has maintained a uniform display without crosstalk. When Chinese characters or alphabet are continuously employed, the uniform display without crosstalk has been maintained with suppression of generation of distortion voltage in the scanning electrode.

COMPARISON EXAMPLE TO EMBODIMENT 4

The wiring 717 of the voltage detecting electrode 701 has been removed from the liquid crystal display device of the embodiment 4. Thus, the liquid crystal display device, in which the same function as the conventional liquid crystal display device is made up by stopping function of the negative feedback loop, is allowed to display under the same condition as in the embodiment described above.

First, an entire display is made white. Thereafter, a black and white horizontal strip pattern is displayed in a region of vertical 100 dots X horizontal 10 dots adjacent to a display center, continuously the number of dots at horizontal of the region is gradually increased up to 300 dots. But, from around the time that the black and white horizontal strip pattern is displayed in the region of vertical 100 dots X horizontal 10 dots, a crosstalk darker than its periphery is generated on its vertical direction. The horizontal dot number of the display region is gradually increased, the crosstalk in vertical direction has been more remarkably generated, its display quality has been considerably deteriorated. When the Chinese characters and alphabet are continuously displayed, then the remarkable crosstalk chained to vertical and horizontal directions is generated to produce a conspicuous irregularity and to lower the display quality.

EMBODIMENT 5

The liquid crystal display element 7 in the liquid crystal display device of the embodiment 4 is modified to a liquid crystal display element 1101 with a construction in FIG. 11 for this embodiment 5. The liquid crystal display element 1101 is characterized by including a resistor element 1103 having a specific electric resistance as a means for detecting voltage other than the voltage input terminal 13 of each scanning electrode 1 in stead of, in the embodiment 4, the static capacitance 705 formed of the voltage detecting electrode 701, the scanning electrode 1, and the liquid crystal layer 5. The same numerals are given for the same parts as those in the embodiments 1 to 4.

Each scanning electrode 1 is connected with the resistor element 1103, through which a voltage of the scanning electrode 1 is detected by the voltage detecting electrode 701. Then, one end of the each resistor element 1103 is connected each of the scanning electrodes 1 respectively, and another end thereof is connected together (commonly) with the voltage detecting electrode 701.

The resistor element 1103 is formed as a film thickness resistor obtained by printing a resistance body between the respective scanning electrode 1 and the voltage detecting electrode 701. The resistor element 1103 is formed to have an electric resistance of 1 MΩ by suitably setting a film thickness, a width of the resistor body, and a length. The voltage detecting electrode 701 detects a voltage from each scanning electrode 1 through the resistor element 1103. The voltage detected by the voltage detecting electrode 701 is input, to the operational amplifier 703 for outputting the scanning non-selected voltage (Vcom), through both the wiring 717 connected with the voltage detecting electrode 701 and the input terminal 17 and the buffer 721 in FIG. 10, and then negative fed back to the scanning electrode 1 from the operational amplifier 703.

In the liquid crystal display device of this embodiment 5, here as in the embodiment 4, the voltage of all the scanning electrodes 1 is detected together through the voltage detecting electrode, and thus detected voltage provides the negative feedback control to the scanning electrode, accordingly even when the voltage of the scanning electrode 1 arranged in a row produces voltage variation such as distortion and the like by receiving induction or external disturbance from the signal electrode 3, then the voltage variation such as distortion and the like are canceled. In this way, the voltage variation such as distortion voltage and the like of the scanning electrode 1 is eliminated, and as a result, the crosstalk of the display image is stopped.

The liquid crystal display device described above is driven to display by the liquid crystal driving voltage of the waveform with polarity inverted with respect to the scanning pulse and the data signal in FIG. 4 under the driving condition of a duty ratio of 1/200, a bias ratio of 1/13, and a frame frequency 80 Hz, and its display quality is visually inspected.

After the entire display is made white, then white and black horizontal strip patterns is displayed on a region of vertical 100 dots x horizontal 10 dots adjacent to a center of the display, continuously the dot number of horizontal of the region is gradually increased up to 300 dots, as a result of these, any of cases

1301 of the liquid crystal display device constructed as above. In an equivalent circuit, static capacitance 1333 is arranged by the scanning line voltage detecting section 1331 and the scanning lines 1301 and the liquid crystal layer 1315. For the static capacitance 1333 there have been prepared one construction using the liquid crystal layer 5 as dielectric in FIG 14(b) and another construction formed of the scanning signal detecting section 1331 of the electrode shape provided on a SiO_2 thin film 1335 as dielectric layer formed immediately above the scanning lines 1301 in FIG. 14 (c).

The scanning driver circuit 1319 inputs, a voltage received from an input terminal 1337, into the operational amplifier 1328 through a buffer 1339. The voltage detected by the scanning signal detecting section 1331 is connected to the scanning signal control terminal 1337 and to be negative fed back to the scanning lines 1301 by the operational amplifier 1328.

Thus, even when the voltage of the scanning lines 1301 receives variation such as voltage distortion and the like by external disturbance such as a data signal and the like, such voltage variation is detected to be negative fed back to the scanning lines 1301 and to operate for canceling the voltage variation. In this way, the crosstalk of the display is eliminated.

The liquid crystal display device, in which at least a part of the scanning lines 1301 is included in the negative feedback loop, is capable of effectively eliminating the voltage distortion of the scanning electrode and realizing a satisfactory display without crosstalk even with any driving method used; namely, the H line inversion driving system for driving with inversion of a polarity of the data signal at every scanning selected period basis; the V line inversion driving system for driving with inversion of a polarity of the data signal at every data line basis concurrently with inversion of the same at every frame basis; and the H common inversion driving system for driving with inversion of voltage of the counter electrode at every scanning selected period basis.

EMBODIMENT 8

The scanning electrode 1 of the liquid crystal display device of the embodiment 4 is formed of the transparent conductive film such as ITO, which however has relatively higher electric resistance as an electric conductive material. Accordingly, the use of such electric resistance provides difference between voltage on supply end side and voltage on terminus side of the scanning electrode 1, this causes a difference between the generating ways of each voltage variation to be a cause of the crosstalk.

To carry out a negative feedback control by further accurately detecting the voltage variation generated in the scanning electrode, a liquid crystal display element of this embodiment 8 in FIG. 15 has been used.

In detail, two of voltage detecting electrodes 1501, 1503 in an electrode shape (strip shape) substantially the same as in the signal electrode 3 are formed opposing to the scanning electrode 1 through the liquid crystal 5 respectively on the supply end and terminus portion of the scanning electrode 1. Thus, static capacitance in the liquid crystal 5 as dielectric is formed on both the supply end and terminus portion of the each scanning electrode 1. The two voltage detecting electrodes 1501, 1503 are connected to the operational amplifier 703 through the input terminal 17, the wiring 717, and buffer 721 the same as in the embodiment 4 and the other, thereby the negative feedback loop is formed.

In the liquid crystal display device of the embodiment 8, constituent elements other than the two voltage detecting electrodes 1501, 1503 and the constituent elements relating thereto are the same as in the embodiment 4.

The liquid crystal display device of the embodiment 8 is driven to display various test patterns under the same condition as the embodiment 4, then it has been confirmed that in any of cases above a satisfactory uniform display is realized over an entire display surface without crosstalk.

In this way, the voltage detecting electrodes 1501, 1503 are arranged respectively on the power supply end and the terminus portion of the scanning electrode 1 to form the negative feedback loop from the power supply end to the power supply end and the negative feedback loop from the terminus portion to the power supply end, the scanning electrode voltage at the power supply end and the scanning electrode voltage at the terminus portion each of the scanning electrode 1 are detected to produce an arithmetical mean thereof, thereby a more accurate detect of the scanning electrode voltage is provided over the entire display surface to cancel a troublesome voltage variation such as a voltage distortion and to further effectively suppress the crosstalk for realizing a satisfactory display.

It is of course that further the several number of voltage detecting electrodes may be provided to detect correspondingly more voltages of a plurality of positions.

characters and alphabet are displayed, similarly the crosstalk is generated with deterioration of the display quality.

EMBODIMENT 10

A liquid crystal display device of an embodiment 10 is characterized in that the waveform distortion of the voltage at the scanning non-selected time is canceled by performing the negative feedback control for the scanning non-selected voltage, simultaneously, the waveform distortion of the scanning pulse is suppressed in a way that the scanning selected voltage, i.e., a rise waveform and a fall waveform of the scanning pulses are made into a dull (delayed) waveform such as a sinusoidal waveform.

Specifically, by adding a sinusoidal shaped waveform generating section to the driving voltage supply circuit 719 described in the embodiment 4 and so forth, a waveform of the scanning pulses (+Vy, -Vy) is changed into the sinusoidal wave for outputting. The other portions are substantially the same construction as the liquid crystal display device described in the embodiment 4 and the others.

A sinusoidal shaped waveform generating section 1801 in FIG. 18 essentially includes a D/A converter 1803, a ROM 1805, and an address counter timing circuit 1807.

The address counter timing circuit 1807, in synchronization with a LP signal, receives a CP signal and starts to count, and to read sinusodial waveform data previously stored in the ROM 1805. Then, with reference to this sinusodial waveform data, the D/A converter 1803 generates an actual sinusoidal wave to output to the operational amplifier 1601 through a buffer 1809 and a capacitor 1811. Thus obtained sinusoidal wave, the LP signal, and the CP signal are respectively shown in FIGs. 19 (a), (b), and (c).

Waveforms of the scanning pulses (+Vy, -Vy) in the liquid crystal display device of the embodiment 10 become sinusoidal waves in FIG. 20(a) which are voltage waves hardly affected by harmonics. In this manner, by making the waveforms of rise and fall of the scanning pulses to be dull, a distortion or the like of the voltage waveform generated by receiving induction and the like from the data signal of the signal electrode 3 at the selected time of the scanning electrode 1 is changed into inconspicuous one, an adverse influence to the image display is sufficiently suppressed. Of course, it is required that the sinusoidal waveform is previously set for preventing the liquid crystal driving from being disturbed by an effective value of the then scanning pulse, and this set value is stored into ROM 1805 for forming such sinusoidal waveform as sinusoidal waveform data.

On the other hand, the voltage distortion at the scanning non-selected time of the scanning electrode 1 is canceled by carrying out the negative feedback control for the scanning non-selected voltage as is the cases of the embodiments 4 and 7 and the others described. Accordingly, it is needless to say that distortion of the scanning non-selected voltage of the scanning electrode 1 is eliminated.

It is apparent that two voltage detecting electrodes 1501, 1503 or further the more number of voltage detecting electrodes of the embodiment 8 described may preferably be employed also in this embodiment 10.

The liquid crystal display device of this embodiment 10 is driven to display by a driving voltage waveform in FIG. 20 at a duty ratio of 1/200, a bias ratio of 1/13, and a frame frequency of 80 [Hz], and its display quality has visually been inspected. Once the entire display is made white, then a white and black horizontal strip patterns is displayed on a region of vertical 150 dots x horizontal 10 dots adjacent to a center of the display, a uniform display without crosstalk is obtained. Continuously, the dot number of horizontal direction of the region is gradually increased up to 500 dots, a display irregularity is not generated, a satisfactory display has been maintained. When Chinese characters or alphabet are continuously displayed, it has been confirmed that a satisfactory display without crosstalk is realized.

EMBODIMENT 11

A liquid crystal display device of an embodiment 11 is characterized in that the waveform distortion of the voltage at the scanning non-selected time by performing the negative feedback control for the scanning non-selected voltage is canceled, concurrently, the waveform distortion of the scanning pulse is suppressed by way that the scanning selected voltage, ie., a rise waveform and a fall waveform of the scanning pulses are made into a dull (delayed) waveform.

Specifically, by adding a dull shaped waveform generating section to the driving voltage supply circuit 719 described in the embodiment 4, waveforms of the scanning pulses (+Vy, -Vy) are changed into the sinusoidal shape for outputting. The other portions are substantially the same construction as the liquid crystal display device described in the embodiment 4 and the others.

scanning pulse and a voltage V_{5Y} at the polarity inverting time thereof each during a scanning selected period, and further a voltage V_1 and a voltage V_4 at the polarity inverting time thereof each during the scanning non-selected period. For a voltage waveform applied to the signal electrode 3 in FIG. 24 (b), a data signal of one frame period is fluctuated centered on the voltage V_4 to become a voltage V_3 or a voltage V_5. At its polarity inverting time, it is fluctuated centered on the voltage V_1 to become a voltage V_0 or a voltage V_2. A liquid crystal applying voltage waveform obtained by way that the voltages described are applied to each predetermined scanning electrode and signal electrode to be overlapped with the liquid crystal layer, becomes a waveform that is polarity inverted at every frame basis, as shown in FIG. 24 (c). Actually, a liquid crystal display device capable of producing a high fine image display uses many times such driving voltage waveform.

The embodiment 12 is characterized in that the voltage variation such as voltage distortion generated in a liquid crystal display device using a driving voltage waveform immediately previously described is suppressed by a negative feedback control. The same numerals are given for the same parts as those of the liquid crystal display device of the embodiment 4 and so forth.

In detail, in FIG. 25, a scanning driver circuit 9 includes a shift register 707 and a switching section 709. In the shift register 707, the scanning data for selecting the scanning electrode 1 sequentially along a row is transferred at one after another basis of the scanning electrode 1. In the switching section 709, scanning pulses (V_{0Y}, V_{5Y}) at the scanning selected time and voltages (V_1, V_4) at the scanning non-selected time are selected by the scanning data. The scanning driver circuit 9 is controlled by FP (frame pulse) for determining one frame and by LP (latch pulse) for determining the one scanning time. To prevent deterioration due to applied direct-current voltage component, liquid crystal is required to be driven by alternate-current voltage, then these switching sections 709 are provided with function for inverting the polarity at a predetermined period, which is controlled by FR (polarity inversion) signal in FIG. 26 (b) given from a control section 2501.

A data driver circuit 11 includes a sift register 711 for transferring DATA (display image data) given from a control section 2501, a data latch 713 for storing the DATA, and a switching section 715 for selecting data signals (V_0, V_2, V_3, V_5) by the DATA. The data driver circuit 11 is controlled by receiving CP (clock pulse), LP (latch pulse), FR (polarity inversion signal), and DATA (display image data) each sent from the control section 2501.

A driving voltage supply circuit 719 is formed inside a scanning driver circuit 9 and the data driver circuit 11.

The driving voltage supply circuit 719 receives power supply voltage supplied from a liquid crystal driving voltage power supply (not shown) to produce respective voltages (V_0, V_1, V_2, V_3, V_4, V_5, V_{0Y}, V_{5Y}) required for driving the liquid crystal display element. In FIG. 26 (a), the input power supply voltage is divided by electric resistances (R_3) 1601, (R_4) 1203, and driving voltages of obtained different potentials are output through each buffer using operational amplifiers 2605, 2607, 2609, 2611, 2613, 2615. The voltages V_{0Y}, V_1, V_4, V_5 from among the respective voltages are supplied to the switching section 709 of the scanning driver circuit 9, and V_0, V_2, V_3, V_5 from the same are supplied to the switching section 715 of the data driver circuit 11.

The switching section 709 of the scanning driver circuit 9 selects respective output voltage potentials one after another from V_{0Y}, V_1, V_4, V_{5Y} ranging from the scanning electrodes Y_1 to Y_{200} in accordance with the scanning data from the control circuit 2501. Specifically, in the switching section 709, if contents of the scanning data thus input is a scanning selected data, the control selects V_{0Y} as a scanning pulse (because of alternate-current driving, this scanning pulse is voltage V_{5Y} at the time of polarity inversion), and if the contents of the scanning data thus input is a scanning non-selected data, the control selects a scanning non-selected voltage V_4 (because of alternate-current driving, a voltage is V_1 at the time of polarity inversion), and the selected are sent to the respective scanning electrode. Thus, for example, the scanning electrode voltage waveforms are obtained by a general voltage averaging method in FIG. 24 (a).

The data driver circuit 11 selects at every one basis a voltage from the voltages V_0, V_2, V_3, V_5 to be applied to each of the 640 signal electrodes 3 ranging from X_1 to X_{640} in accordance with display image data obtained from the control circuit 2501, and the selected voltages are applied to the respective signal electrodes 3.

When the display image data (DATA) is input to the shift register 711, the control proceeds to sequentially transfer as serial data from X_1 to x_{640} in accordance with the clock pulse (CP) inside such shift register 711. Inside the data latch 713, the display image data (DATA) serially transferred by the shift register 711 are respectively stored as 640 parallel data ranging from outputs X_1 to x_{640} in accordance with LP (latch pulse) at every data latch element basis with the numerals of 640 arranged in rows in a manner of an array. In the switching section 715, at every data basis in accordance with parallel data stored in the data

First, the entire display surface is made white, thereafter a white and black horizontal strip pattern is allowed to display on a region vertical 150 dots x horizontal 10 dots, then continuously, the horizontal dot number of this region is gradually increased up to 500 dots. But, when the white and black horizontal strip pattern is allowed to display on the region vertical 150 dots x horizontal 10 dots, then a darker crosstalk portion of the display than that of its periphery is more remarkably generated in the vertical direction, and depending on the increase of this horizontal dot number, a vertical crosstalk is also remarkably appeared and deteriorate the display quality. When the Chinese characters and alphabet are displayed, similarly the remarkable crosstalk chained to the vertical and horizontal directions is generated, to conspicuously provide irregularity of the display, and to lower the display quality.

EMBODIMENT 13

The liquid crystal display element of the liquid crystal display device of the embodiment 12 is changed into a construction formed of the liquid crystal display element 7 using the two voltage detecting electrodes 1501, 1503 of the embodiment 8 in FIG. 15. The other constituent elements are the same as in the embodiment 12. A voltage variation of the scanning electrode 1 is more accurately detected by using a plurality of voltage detecting electrodes as equivalent as in the embodiment 8 and the others described.

A liquid crystal display device of this embodiment 13 is allowed to display with a polarity inversion at every 13 scanning line basis at a duty ratio of 1/200, a bias ratio of 1/13, and a fame frequency of 80 Hz, and its display quality has been visually inspected, as in the embodiment 12.

First, the entire display is made white, then white and black horizontal strip patterns are displayed on a region of vertical 150 dots x horizontal 10 dots adjacent to a center of the display, continuously, the dot number of horizontal of the region is gradually increased up to 500 dots, and in any cases a satisfactory uniform display without crosstalk has been maintained. When Chinese characters or alphabet are continuously displayed, generation of the distortion voltage in the scanning electrode is suppressed, and a satisfactory display without crosstalk is maintained. In this case, the crosstalk on the display is more suppressed compared to the embodiment 12.

EMBODIMENT 14

The negative feedback control to the scanning non-selected voltage is employed in the embodiment 12. However, the negative feedback control is performed also for the scanning pulse to eliminate the voltage variation such as a voltage distortion generated in the scanning pulse during the scanning selected period and to more effectively suppress the crosstalk.

In this case, as shown in FIG. 28, a circuit may preferably be constructed that an output of the operational amplifier 2621 is input not only to the operational amplifiers 2607, 2613 through the capacitor 2801, but also to the operational amplifiers 2605, 2615 through the same.

EMBODIMENT 15

An embodiment 15 is in that two voltage detecting electrodes 1501, 1503 of the embodiment 13 or further a plurality of voltage detecting electrodes are used in the embodiment 14. Thus, a voltage variation of the scanning electrode 1 is more accurately detected.

EMBODIMENT 16

In the liquid crystal display device of the embodiment 12, the control circuit 2501 is changed into one capable of performing 16 gradation representation of the pulse width modulation system to generate a control signal, concurrently it is changed into MSM 5300 made by Oki Electric Co., Ltd. that is the liquid crystal driver IC of the pulse width modulation system as a data driver circuit 11, and a liquid crystal display device of a pulse width modulation system is produced. In the pulse width modulation system, the minimum unit pulse width is shortened by the amount corresponding to the gradation representation in order to timely control the pulse width depending on the gradation representation. In general, the minimum unit pulse width is determined by a CPG signal divided into the gradation number between latch pulses (LP). In this embodiment 16, a variation of the pulse width for the gradation level is selected for obtaining a uniform change of an optical transmittance of the liquid crystal.

The liquid crystal display device of the embodiment 16 is allowed to perform the gradation representation under the driving condition at a duty ratio of 1/200, a bias ratio of 1/13, and a fame frequency of 80 Hz,

as in an operating temperature, a satisfactory negative feedback control is always performed to eliminate the voltage distortion and voltage variation or the like, in addition, the crosstalk of the display image is always suppressed to realize a high grade of image display.

The liquid crystal display device in this embodiment 18 is driven to display by the liquid crystal driving voltage employed in the described embodiments for performing polarity inversion at every 13 scanning line basis at a duty ratio of 1/200, a bias ratio of 1/13, and a frame frequency 80 Hz, then its display quality has been visually inspected.

First, the entire display is made white, and thereafter a white and black strip shape pattern is displayed on a region of vertical 150 dots x horizontal 10 dots adjacent to a center of the display, continuously, the dot number of horizontal of the region is gradually increased up to 500 dots, and in any cases a satisfactory uniform display without crosstalk has been maintained. When Chinese characters or alphabet are continuously displayed, generation of the distortion voltage in the scanning electrode is suppressed, and a satisfactory display without crosstalk is maintained.

Moreover, the liquid crystal display device of the embodiment 18 is placed under the environment condition of an ambient temperature 50 • C to be display in the way described above, where a uniform display without crosstalk has been maintained over a long time.

Furthermore, the liquid crystal display device of this embodiment 18 is allowed to display as described above under the environmental condition of the ambient temperature 50 • C, similarly a uniform display without crosstalk has been maintained.

Next, the liquid crystal display device of the embodiment 18 is also placed under the environment condition of an ambient temperature 25 • C and lighted continuously during 2000 hours thereafter to be display in the same way as described above, then in this case, also the uniform display without crosstalk has been maintained. Accordingly, it is confirmed from this experimentation that the liquid crystal display device of the invention exhibits a high grade of display characteristic having a satisfactory durability with a high reliability.

EMBODIMENT 19

The negative feedback control has been performed only for the scanning non-selected voltage in the previous embodiment 18. But the same negative feedback control is performed also for the scanning pulse. To realize this, a driving voltage supply circuit 3101 in FIG. 31 is provided in stead of the driving voltage supply circuit 2901 described. In the driving voltage supply circuit 3101, an output from the operational amplifier 2909 is applied not only to V1, V4 but also to V0Y, V5Y, and only the voltage distortion component detected from the scanning electrode is more accurately taken out and negative fed back to V0Y, V5Y.

A plurality of voltage detecting electrodes are further provided, of course, to carry out the positionally more uniform detection for the scanning electrode voltage.

EMBODIMENT 20

FIG. 32 shows a liquid crystal display device of this embodiment 20, which are constituted of a liquid crystal display element 7, a driving waveform control section 3201, a scanning driver circuit 3203, and a data driver circuit 3205.

The liquid crystal display element 7 is the same as in the embodiments described.

The driving waveform control section 3201 in accordance with Active Addressing Driving Method as disclosed in SID, '92, Digest, p.228 to p.231, comprises a display data memory 3207 for temporary holding display data (DATA) being sequentially input, a scanning signal waveform memory 3209 for storing voltage waveform data corresponding to one period (frame) applied to the scanning electrode 1, and an arithmetic circuit 3211 for producing a signal waveform by being computed from the display data and the scanning signal waveform data. In the display data memory using RAM, the display data corresponding to one display picture (640 x 200 dots) being sequentially transferred are once held as an alignment 1 (i, J) of 200 rows, 640 columns (i = 1 - 200, j = 1 - 640), those at every 200 row basis are transferred to an arithmetic circuit 3211 in a parallel way. The scanning signal waveform memory 3209 using ROM, in which voltage waveform data F1 (t) (i = 1 - 200) corresponding to one period supplied to the respective 200 scanning electrodes 1 are written in advance, is output repeatedly in parallel manner to each scanning electrode 1 and the arithmetic circuit 3211. For the voltage waveform, there presents an orthonormal system corresponding to 200 rows taken out from among Walsh orthonormal function, row and column, 256 x 256 formed of binary of -1 and -1.

The signal waveform given by the following equation is computed in the arithmetic circuit 3211,

When a voltage proportional to a sum of the scanning signal waveform data described is used as a reference voltage (V_{ref}) and a distortion voltage component is taken out using a difference between such voltage proportional to the sum and a voltage detected from the voltage detecting electrode 701, then only the distortion voltage component of the scanning electrode 1 is extracted irrespective of voltage waveform to be input. The extracted voltage is negative fed back to the scanning electrode 1 itself through the driving voltage supply circuit, then a voltage variation such as a voltage waveform distortion of the scanning electrode is canceled.

The liquid crystal display device of the embodiment 20 is driven to display at a frame frequency of 80 Hz, and its display quality is visually inspected.

After the display is made white, a white and black strip shape pattern is displayed on a region of vertical 150 dots x horizontal 10 dots adjacent to a center of the display, continuously, the dot number of horizontal of the region is gradually increased up to 500 dots. Then, in any cases a satisfactory uniform display without crosstalk has been maintained. When Chinese characters or alphabet are continuously displayed, a satisfactory uniform display without crosstalk due to the voltage distortion has been maintained.

The Active Addressing Driving Method has hereinbefore been described. In case where the liquid crystal display device is driven by the Multiple Line Method having the same principle as the Active Addressing Driving Method, then it is also a matter of course that the technique of the invention is suitable for reducing the crosstalk. A typical example is newly considered in that the scanning electrodes 1 are divided into 50 groups each having 4 scanning electrodes 1 in the liquid crystal display device of the construction described.

One period (frame) is equally divided into 50 groups as above, each group is given of an orthonormal system data formed of +1 and -1 only during the 1/50 of one period, and the remaining period is rewritten of the memory of the scanning signal waveform memory 3209 for being given 0 data. Following this, the voltage dividing circuit 3401 and the operational amplifier 3403 of the driving voltage supply Circuit 3219 are each increased of one more stage for obtaining ternary of V_1, V_2, V_3 matching to data +1, 0, -1. On driving, where the condition other than used above is allowed to meet those in the liquid crystal display device described, then a voltage waveform applied to the liquid crystal comes to have 4 clear selected pulses during one period (frame).

The liquid crystal display device of this construction is driven to display at a frame frequency of 80 Hz, and its display quality has been visually inspected.

After the display is made white, a white and black strip shape pattern is displayed on a region of vertical 150 dots x horizontal 10 dots adjacent to a center of the display, continuously, the dot number of horizontal of the region is gradually increased up to 500 dots. Then, in any cases a satisfactory uniform display without crosstalk has been maintained. When Chinese characters or alphabet are continuously displayed, generation of distortion voltage is suppressed and a uniform display without crosstalk has been maintained in the scanning electrode.

The voltage detecting electrode 701 in the liquid crystal display element 7 in the embodiments described is not limited to an arrangement on a terminus portion of the scanning electrode 1. For example, it may provide a power supply portion for obtaining a mean value from voltages detected from such both portions.

As hereinbefore fully described, the invention provides a liquid crystal display device capable of solving a disadvantage of generation of the display irregularity (crosstalk) on the display surface by a simple inexpensive means and realizing a high grade of image display.

Claims

1. A liquid crystal display device, comprising a scanning electrode substrate formed of a plurality of scanning electrodes (1), a data electrode substrate comprising thereon a plurality of signal electrodes (3) arranged opposing to an intersecting with a plurality of the scanning electrodes maintaining gaps therebetween, a liquid crystal display panel having a liquid crystal layer (5) sealed and held between the scanning electrodes and the signal electrodes, a scanning driver circuit (9) for applying a scanning signal and a data driver circuit (11) for applying a data signal,

   characterized by

   a wiring (19) connected with its one end to at least a part of each of a plurality of the scanning electrodes so as to directly detect a voltage from a plurality of the scanning electrodes;

   an operational amplifier (15) connected to the other end of the wiring in which a voltage detected from each of a plurality of the scanning electrodes (1) through the wiring is received and a difference between the detected voltage and the scanning signal is computed to be applied to the scanning

signal electrodes (3) and a plurality of the electric capacitances (705) are formed by the voltage detecting electrode (701) the liquid crystal layer and the scanning electrode (1),

the voltage detecting electrode (701) forming an other terminal of the electric capacitances is connected to an input terminal of the operational amplifier (721) takes out a voltage distortion component from the voltage on the scanning electrode (1) by capacitive coupling of the electric capacitance and applies the voltage distortion component to the operational amplifier (721) so that this component is synthesized with at least one from among a plurality of voltage levels being output from the driving voltage supply circuit (719).

6. A liquid crystal display device as claimed in claim 5, wherein

a plurality of the voltage detecting electrodes (701) are formed opposing to a plurality of portions of each of a plurality of the scanning electrodes (1) and

voltages detected on a plurality of the voltage detecting electrodes are combinedly applied to an input terminal of the operational amplifier (721).

7. A liquid crystal display device as claimed in claim 4, 5 or 6, wherein

an operational amplifier (307) is provided by means of which a distortion voltage component taken out from a voltage detected from the scanning electrode (1) is synthesized with a voltage for producing a scanning selected voltage and another voltage for producing a scanning non-selected voltage each being output from the driving voltage supply circuit (719) and

a negative feedback loop for performing a negative feedback control of voltages of a plurality of the scanning electrodes (1) is provided to suppress distortions of a scanning selected voltage and distortions of the scanning non-selected voltage of each of the scanning electrode (1).

8. A liquid crystal display device, comprising a scanning electrode substrate formed of a plurality of scanning electrodes (1), a data electrode substrate comprising thereon a plurality of signal electrodes (3) arranged opposing to and intersecting with a plurality of the scanning electrodes having gaps therebetween, a liquid crystal display panel having a liquid crystal layer (5) sealed and held between the scanning electrodes and the signal electrodes, a driving voltage supply circuit (719) for outputting a plurality of voltage levels for producing a scanning voltage and a scanning non-selected voltage, a scanning driver circuit (9) which has a switching circuit for applying to the scanning electrodes a voltage selected from among a plurality of levels of voltages output from the driving voltage supply circuit (719) and which applies to each of a plurality of scanning electrodes (1) a scanning signal formed by a combination of the scanning selected voltage and the scanning non-selected voltage, and a data driver circuit (11) for applying to each of a plurality of signal electrodes (3) a data signal,

characterized in that

a voltage detecting electrode (701) opposing to a plurality of the scanning electrodes (1) through the liquid crystal layer (5) is formed on the data electrode substrate substantially in parallel with the signal electrode (3) and a plurality of the electric capacitances (705) are formed between the voltage detecting electrode (701), the liquid crystal layer (5) and the scanning electrode (1),

the voltage detecting electrode (701) forming an other terminal of the electric capacitance (705) is connected to an operational amplifier (721) takes out a voltage distortion component from the voltage on the scanning electrodes (1) by capacitive coupling of the electric capacitance (705) and applies the voltage distortion components to the operational amplifier (721) so that this component is synthesized with a voltage for producing a non-selected voltage from among a plurality of levels of voltages being output from the driving voltage supply circuit, and a negative feedback loop for executing a negative feedback control of a scanning non-selected voltage of a plurality of the scanning electrodes (1) is formed to suppress generation of distortion of the scanning non-selected voltage of the scanning electrode; and

a waveform shaping circuit (2101) for making dull (delaying) at least a rising waveform portion or a falling waveform portion of the scanning selected voltage being output from the driving voltage supply circuit (719) is provided on the driving voltage supply circuit to reduce an influence of fluctuation of an effective voltage due to distortion of the scanning selected voltage.

9. A liquid crystal display device as claimed in claim 4, 5, 6, 7 or 8, further comprising:

a reference voltage circuit for producing a reference voltage, and

on operational amplifier (307) receiving a difference between the reference voltage and a voltage detected from the scanning electrode by the voltage detecting electrode (701).

FIG. 1

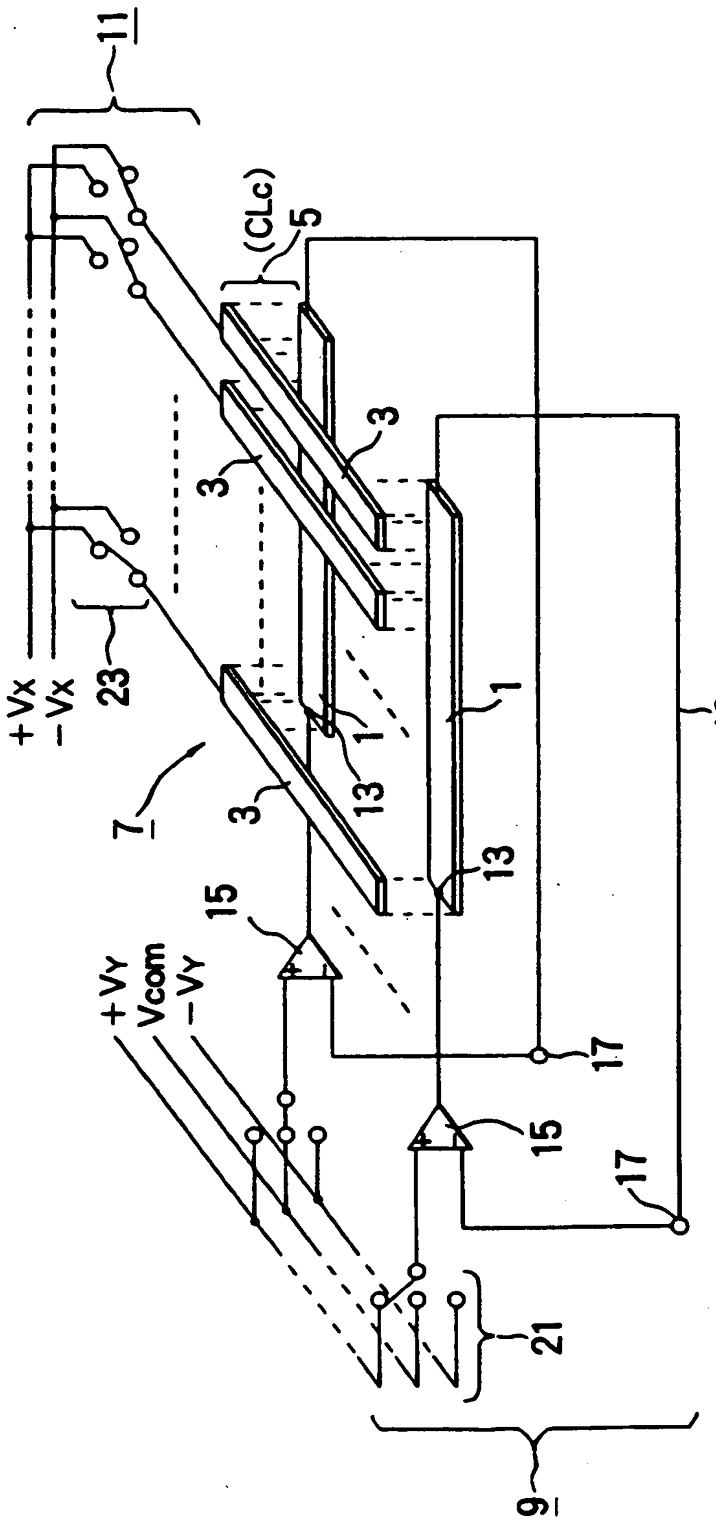


FIG. 2 (a)

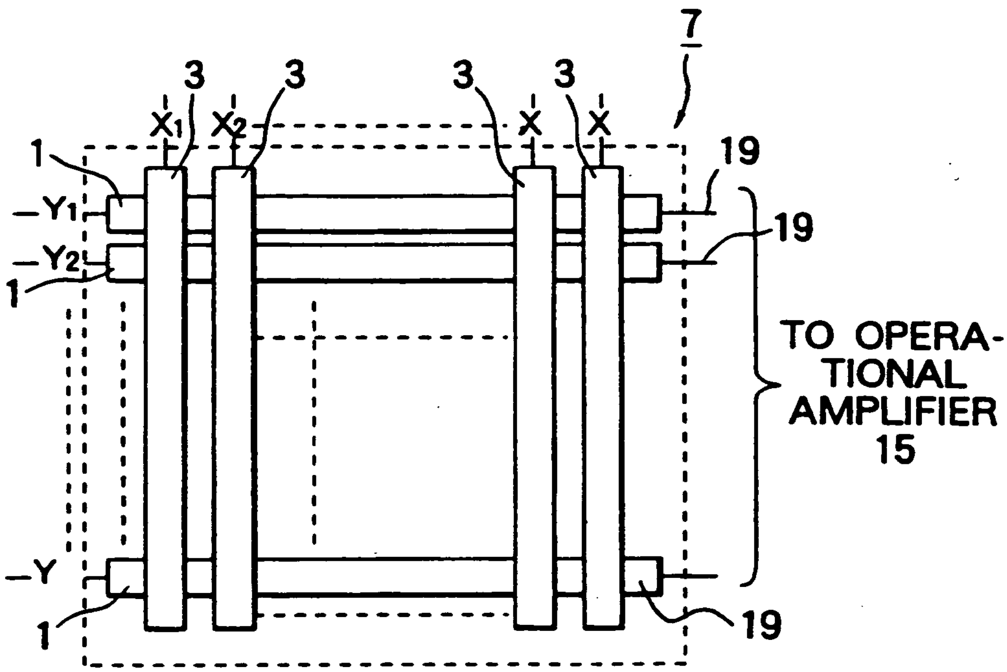

7
3
3
3
3
X1
X2
X
X
1
19
Y1
19
Y2
1
TO OPERATIONAL AMPLIFIER 15
Y
1
19

FIG. 2 (b)

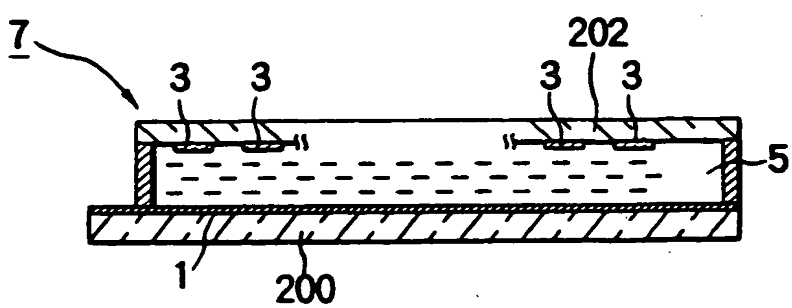

7
202
3
3
3
3
5
1
200

FIG. 3

301

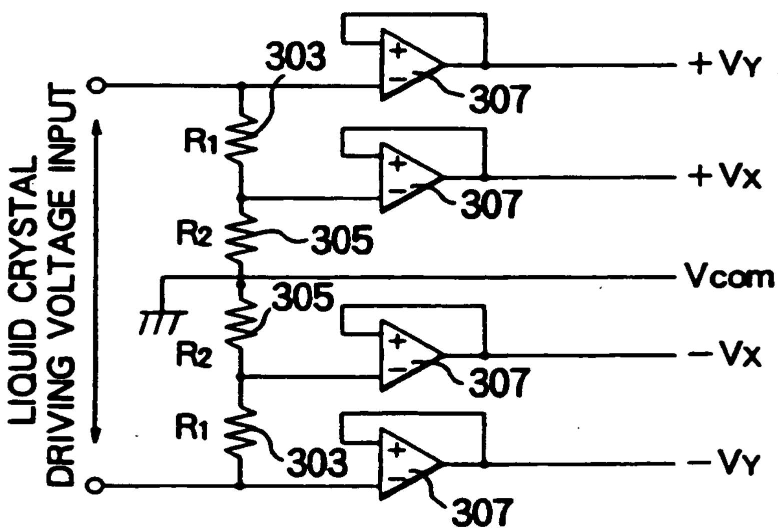
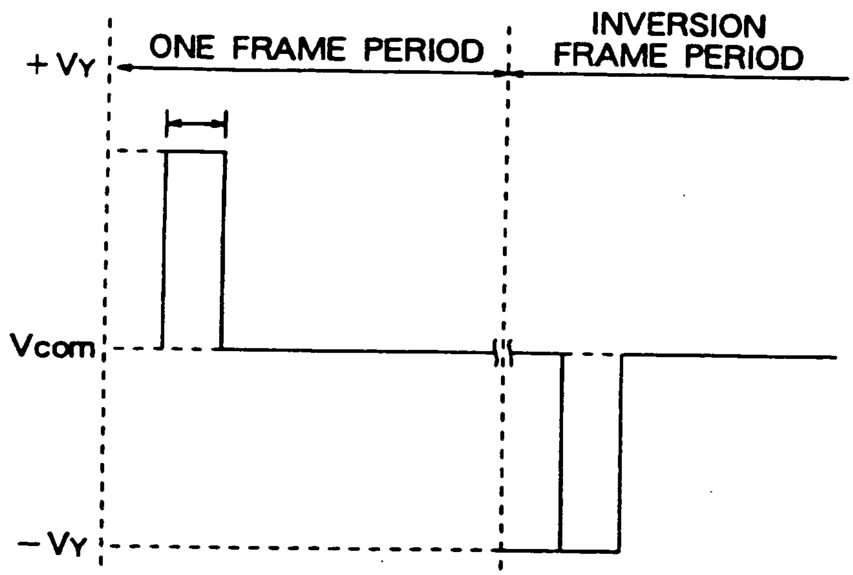
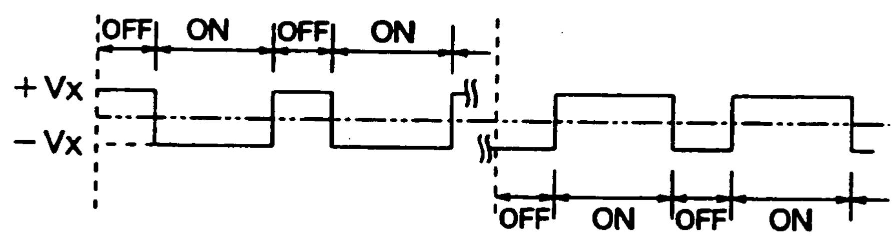

LIQUID CRYSTAL
DRIVING VOLTAGE INPUT
303
R1
R2
305
305
R2
R1
303
307
307
307
307
+VY
+VX
Vcom
−VX
−VY

FIG. 4 (a)



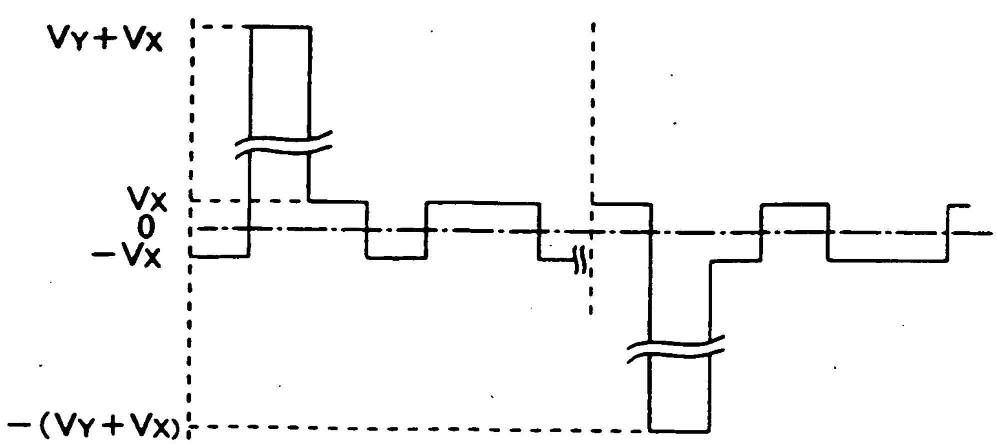
SCANNING SIGNAL WAVEFORM

FIG. 4 (b)



DATA SIGNAL WAVEFORM

FIG. 4 (c)



LIQUID CRYSTAL APPLYING VOLTAGE WAVEFORM

FIG. 5

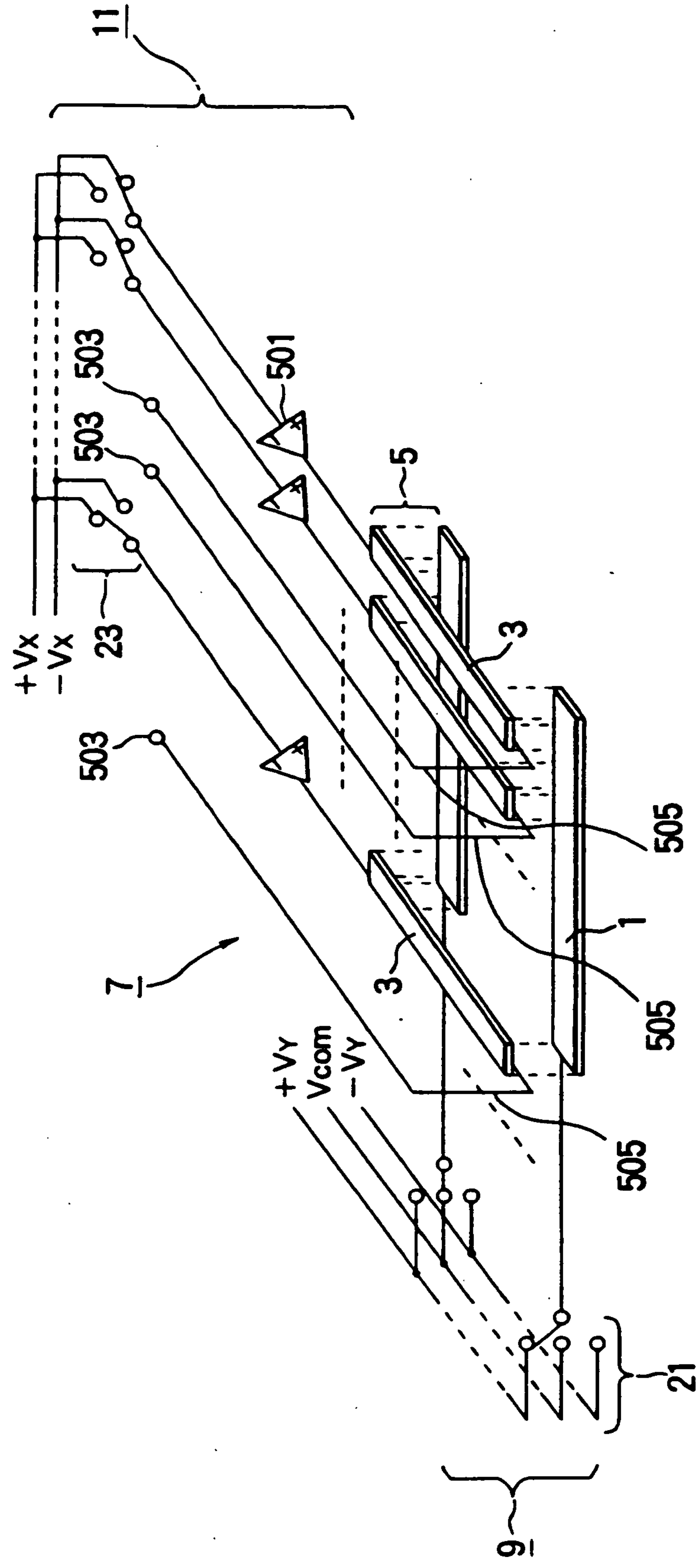


FIG. 6 (a)

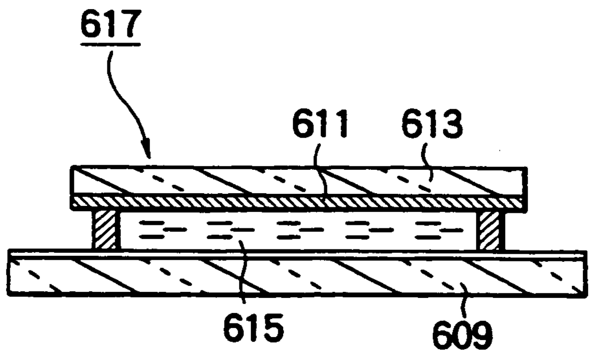
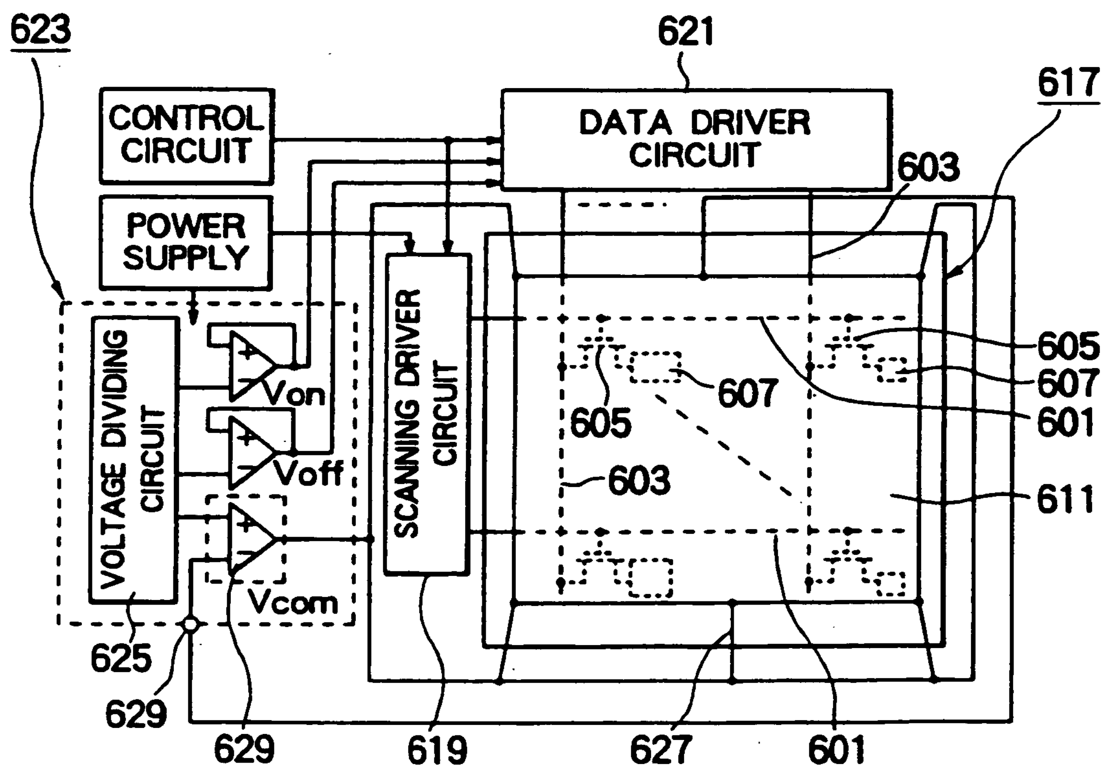

617
611
613
615
609

FIG. 6 (b)


623
621
617
CONTROL CIRCUIT
DATA DRIVER CIRCUIT
603
POWER SUPPLY
SCANNING DRIVER CIRCUIT
VOLTAGE DIVIDING CIRCUIT
Von
Voff
Vcom
605
607
601
603
611
625
629
629
619
627
601

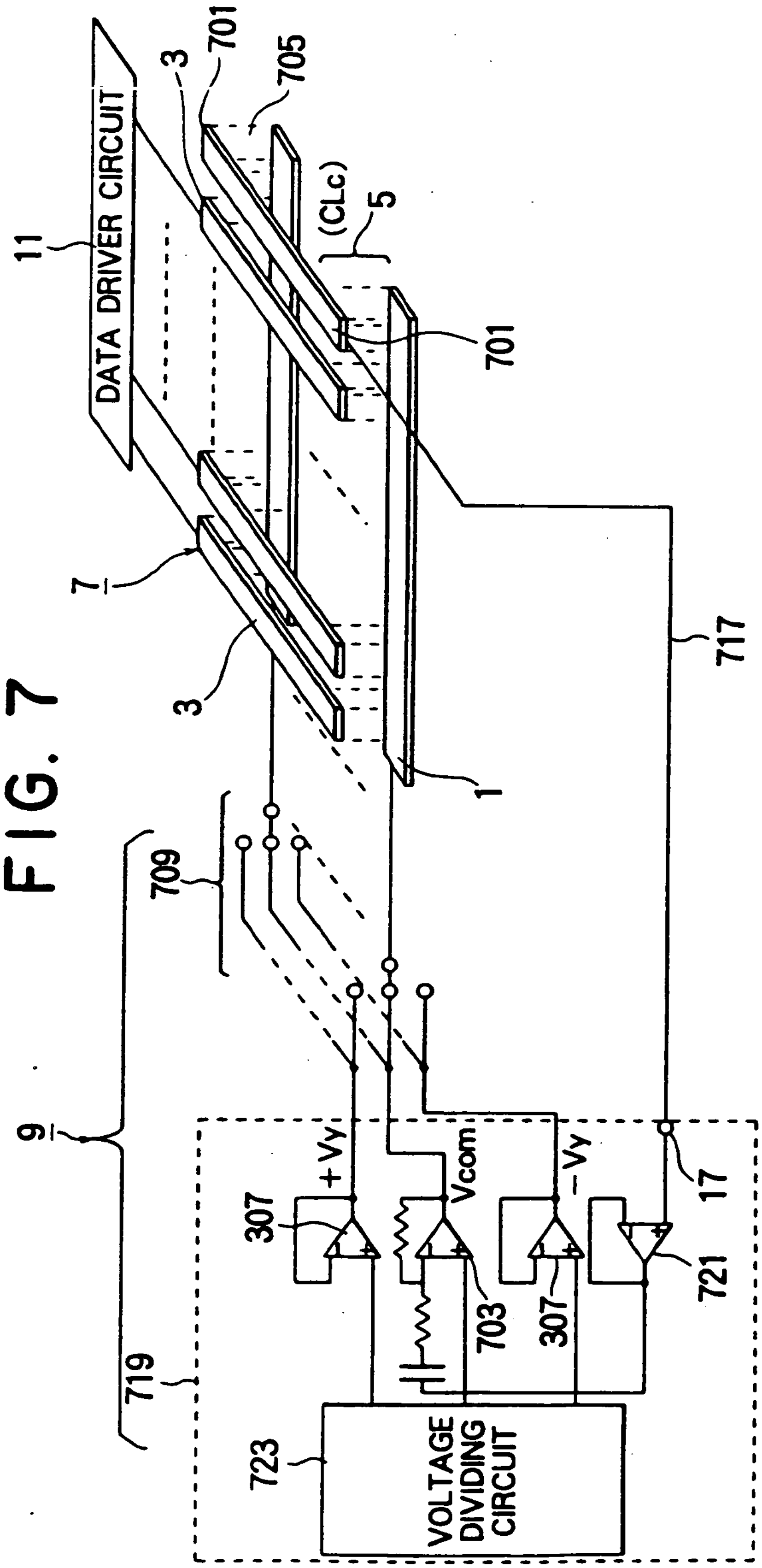

DATA DRIVER CIRCUIT
11
701
705
3
(CLc)
5
701
7
3
1
709
9
+Vy
Vcom
-Vy
17
307
703
307
721
717
719
723
VOLTAGE DIVIDING CIRCUIT

FIG. 7

FIG. 8

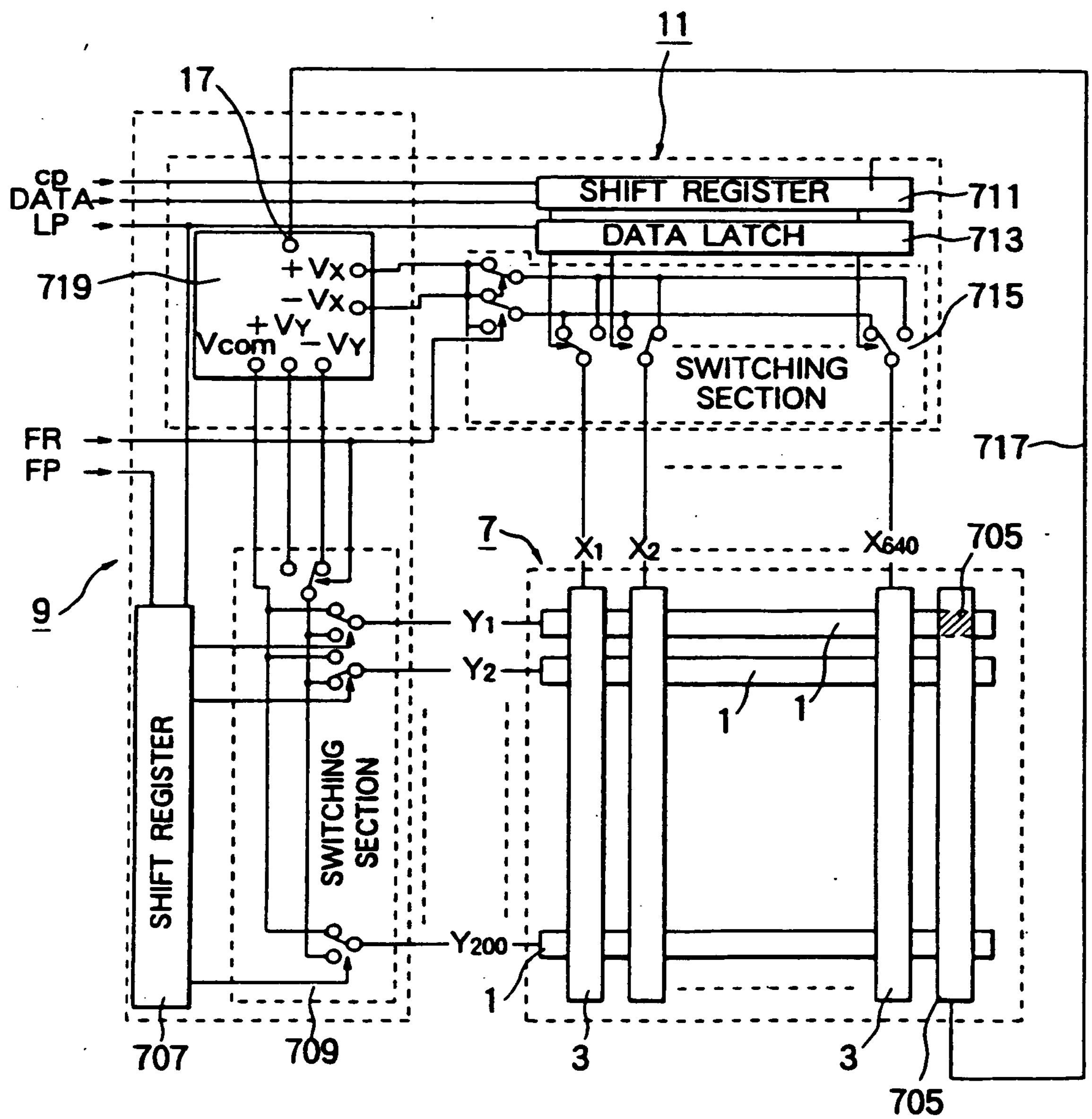

11
17
cp
DATA
LP
SHIFT REGISTER
711
DATA LATCH
713
719
+Vx
−Vx
+VY
Vcom
−VY
715
SWITCHING
SECTION
FR
FP
717
7
X1
X2
X640
705
9
Y1
Y2
1
1
SHIFT REGISTER
SWITCHING
SECTION
Y200
1
707
709
3
3
705

FIG. 9 (a)

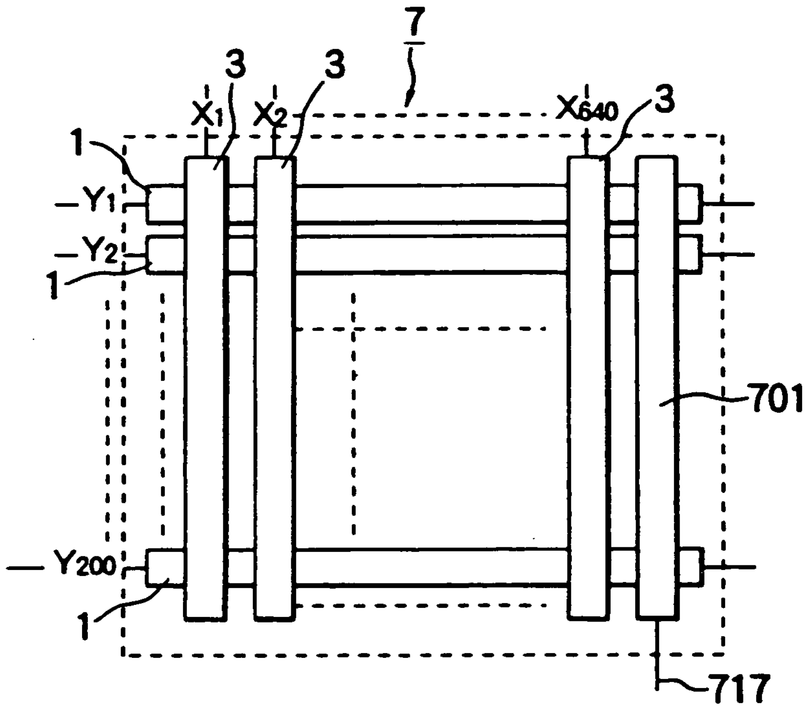


FIG. 9 (b)

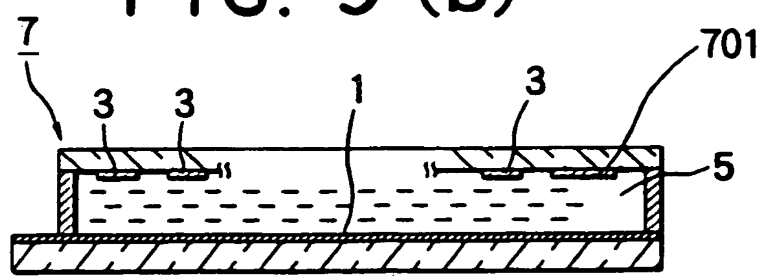
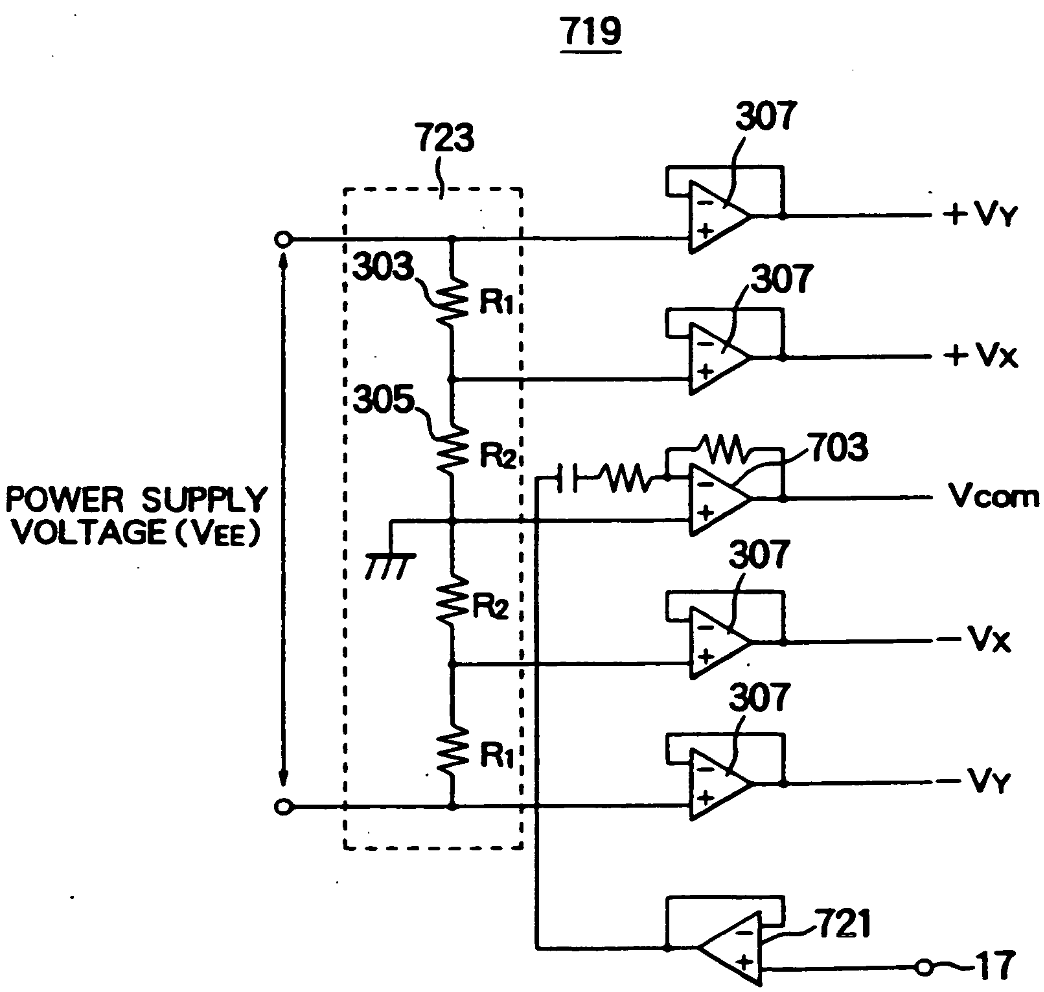


FIG. 10



719
723
307
+VY
303
R1
307
+VX
305
R2
703
Vcom
POWER SUPPLY
VOLTAGE (VEE)
R2
307
-VX
R1
307
-VY
721
17

FIG. 11 (a)

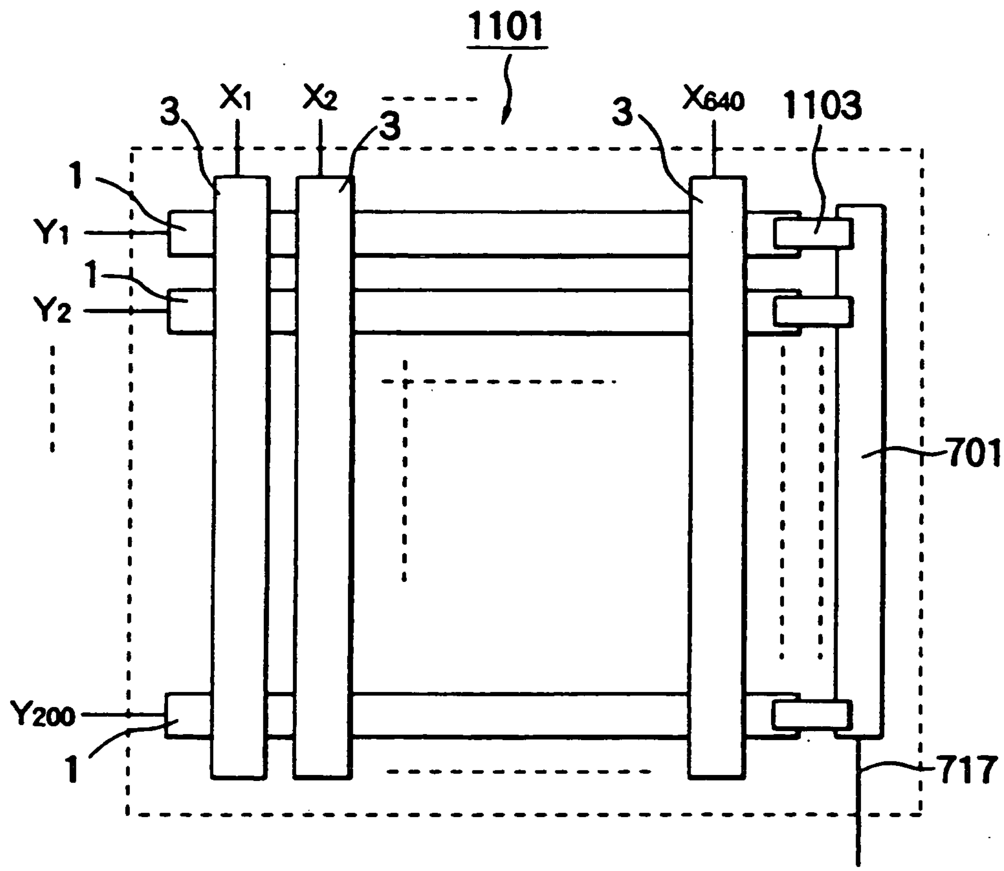


FIG. 11 (b)

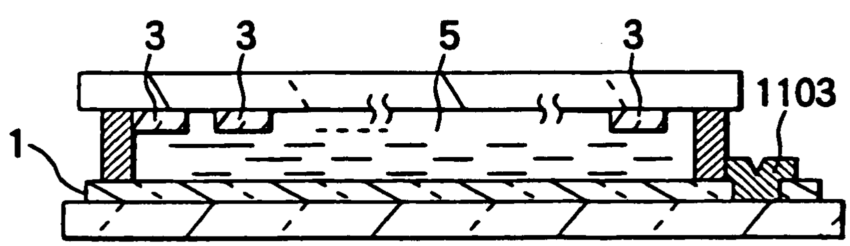


FIG. 12

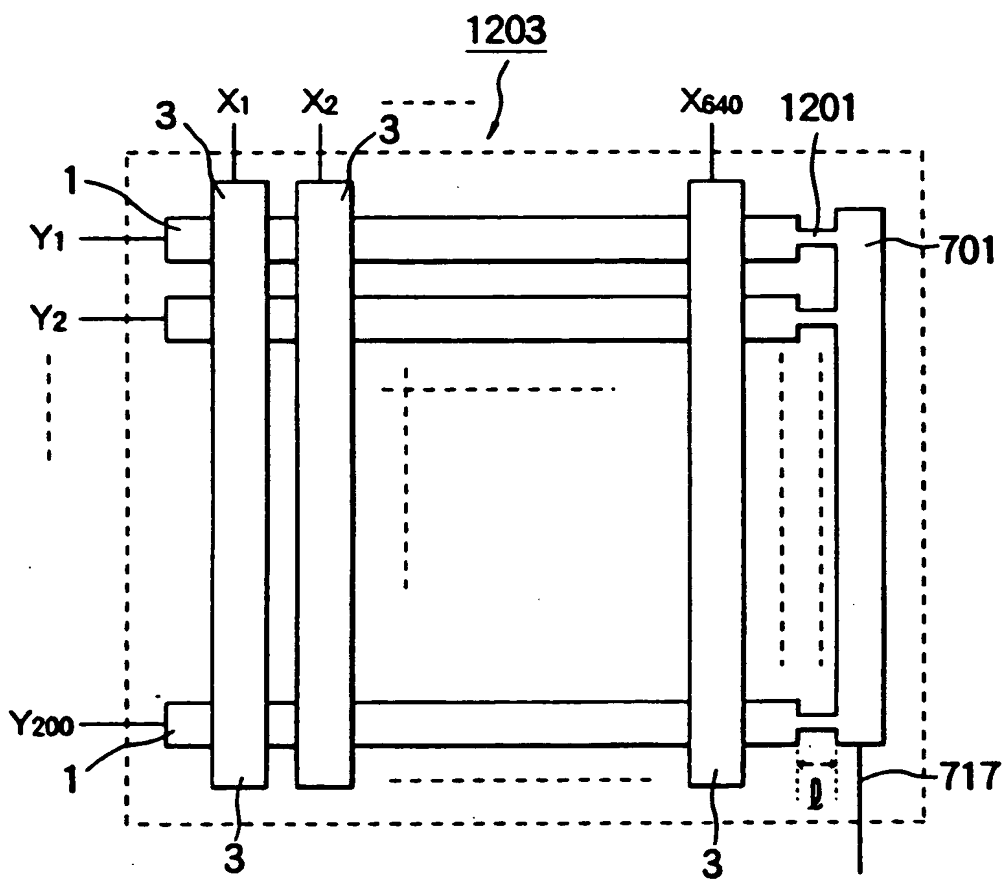


FIG. 13

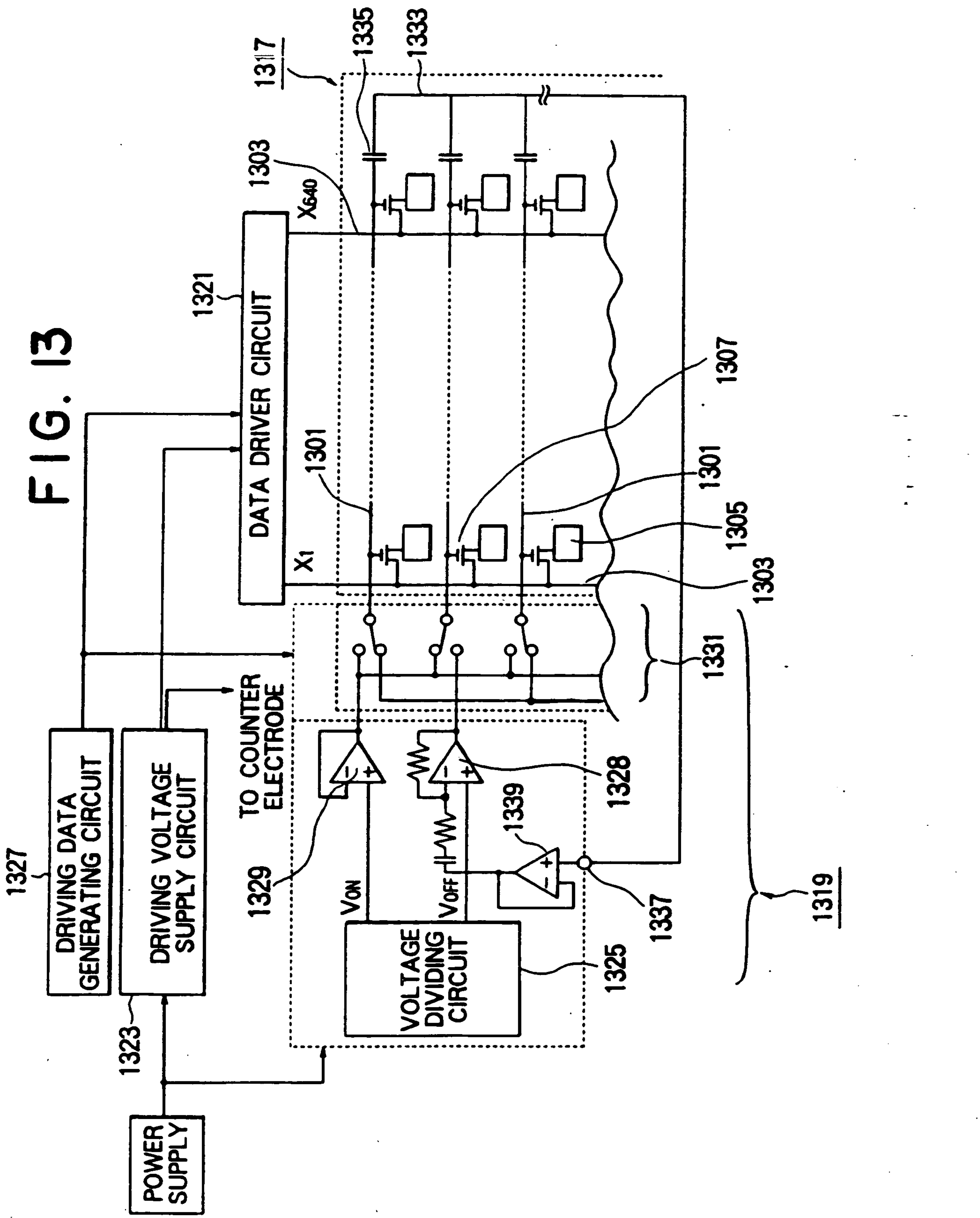

1327
DRIVING DATA GENERATING CIRCUIT
DRIVING VOLTAGE SUPPLY CIRCUIT
1323
POWER SUPPLY
TO COUNTER ELECTRODE
1321
DATA DRIVER CIRCUIT
X1
X640
1303
1301
1317
1335
1333
1307
1305
1331
1328
1329
1339
VON
VOFF
1337
1325
VOLTAGE DIVIDING CIRCUIT
1319

FIG. 14 (a)

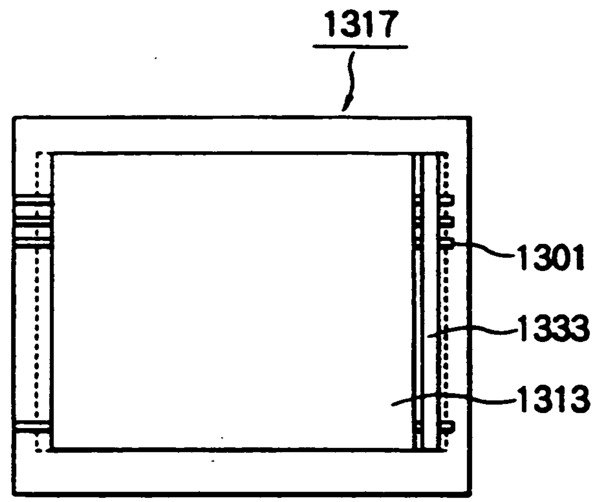


FIG. 14 (b)

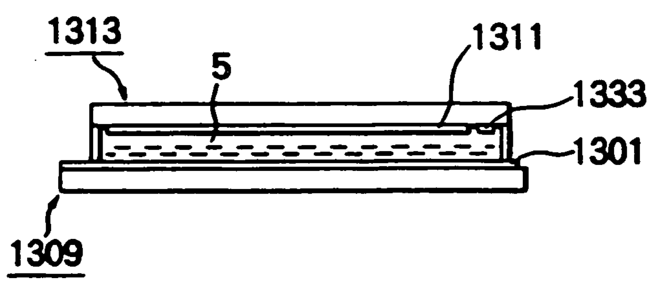


FIG. 14 (c)

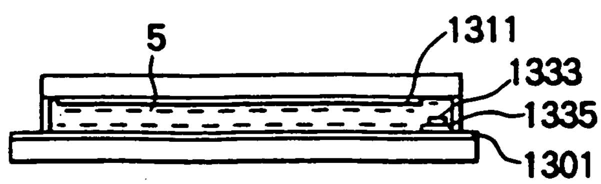
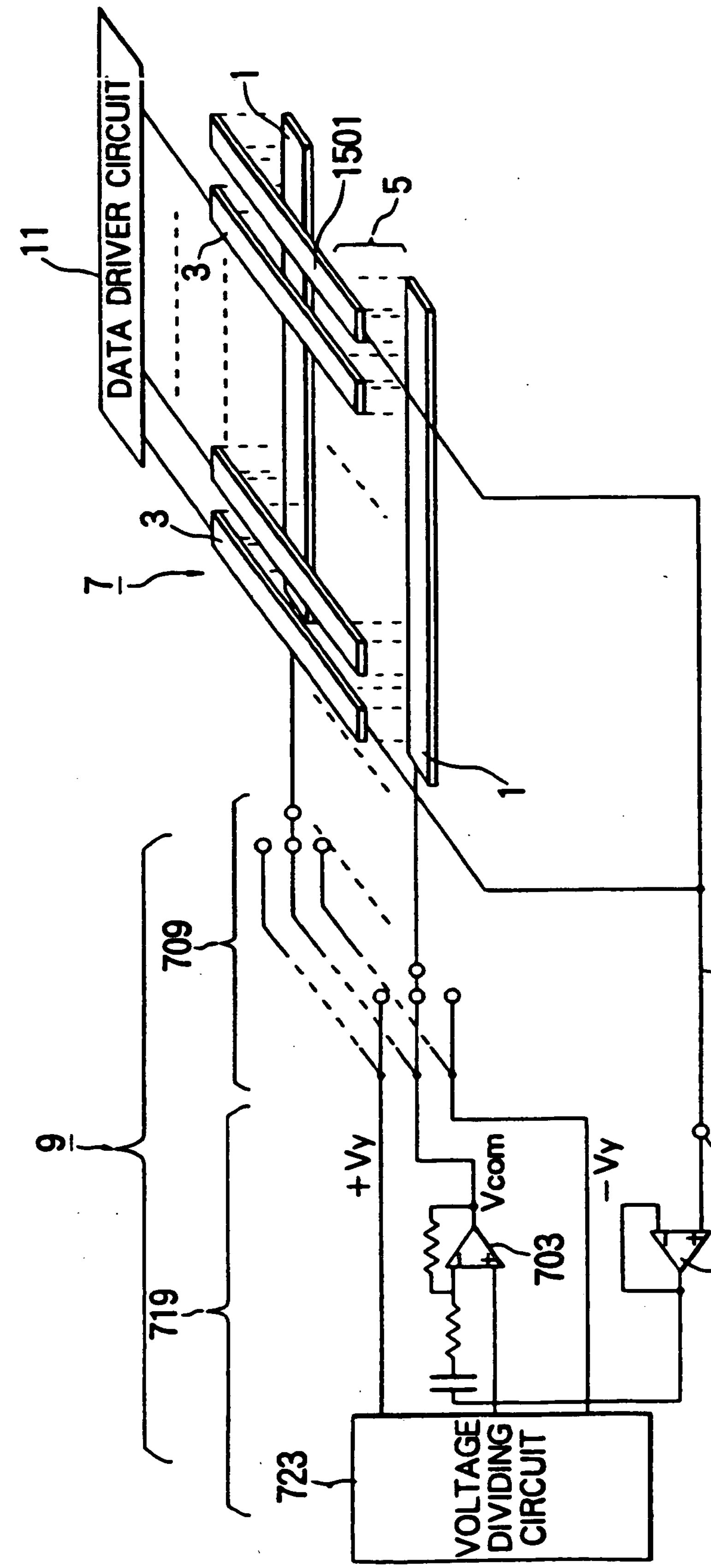


FIG. 15



DATA DRIVER CIRCUIT
11
1
1501
5
3
3
7
1
709
9
719
717
+Vy
Vcom
703
−Vy
17
721
723
VOLTAGE DIVIDING CIRCUIT

FIG. 16

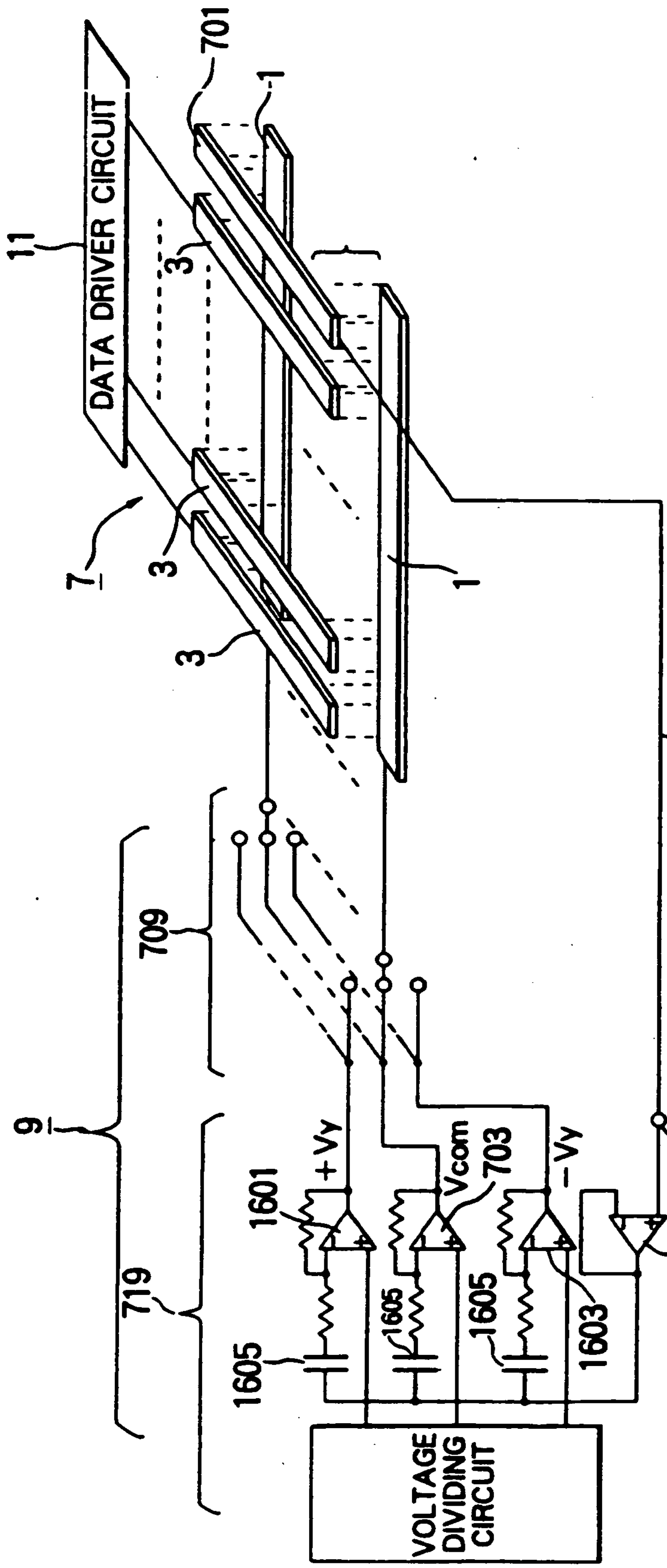

DATA DRIVER CIRCUIT
11
701
1
3
3
3
7
1
717
709
9
719
1601
+Vy
Vcom
703
-Vy
17
1605
1605
1605
1603
721
VOLTAGE DIVIDING CIRCUIT

FIG. 17

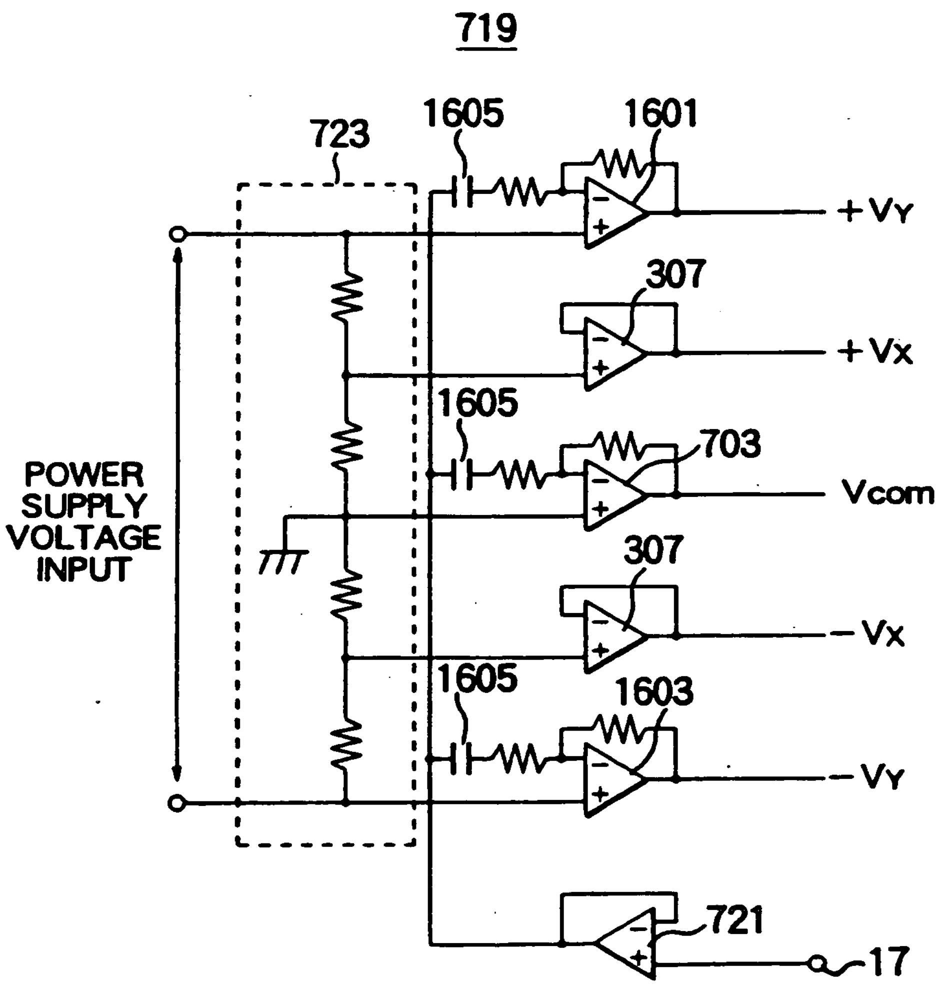

719
723
1605
1601
+VY
307
+VX
1605
703
Vcom
POWER
SUPPLY
VOLTAGE
INPUT
307
-VX
1605
1603
-VY
721
17

FIG. 18

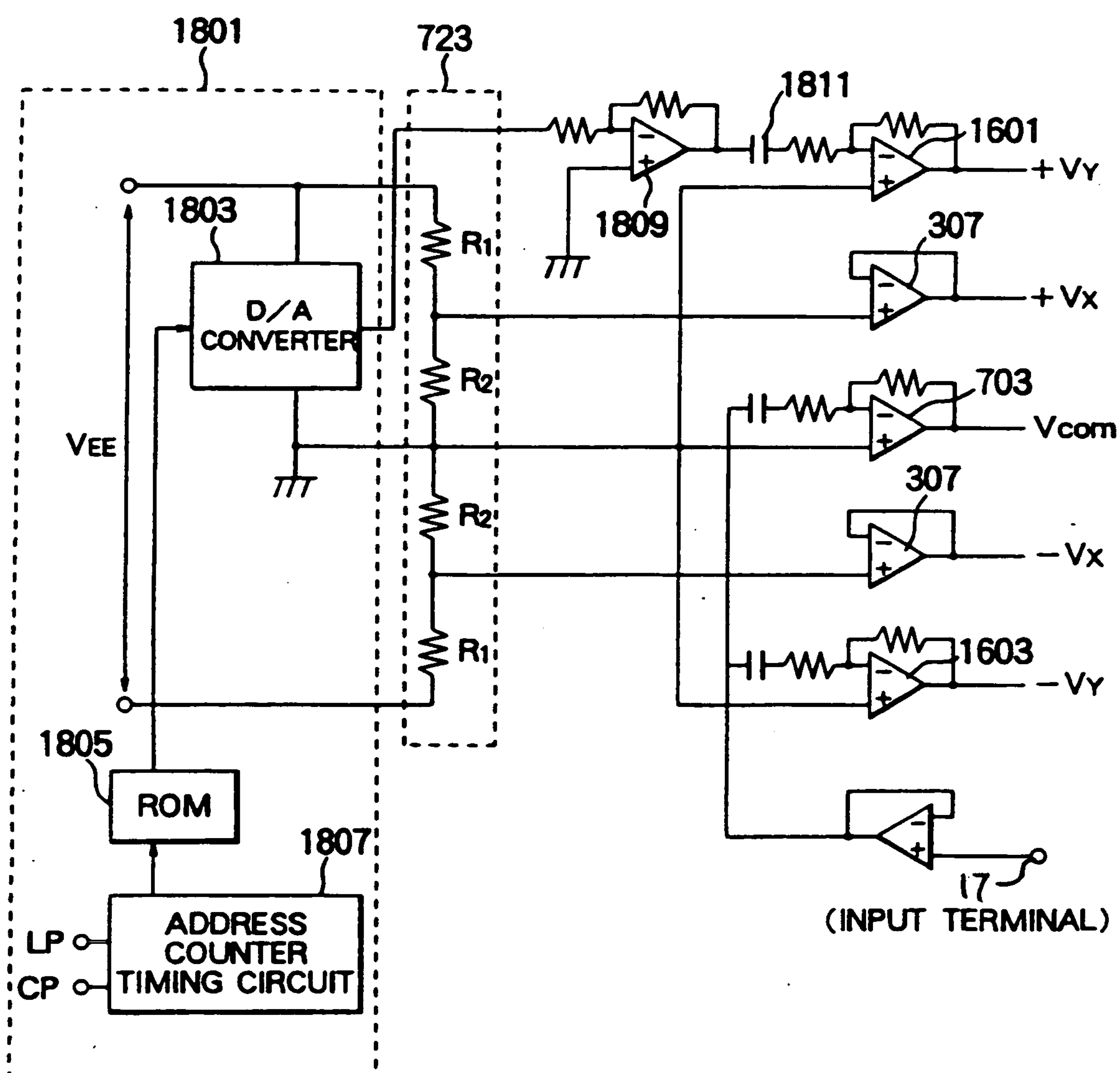

1801
723
1811
1601
+VY
1803
R1
1809
307
D/A CONVERTER
+VX
R2
703
Vcom
VEE
307
R2
-VX
R1
1603
-VY
1805
ROM
1807
17
(INPUT TERMINAL)
ADDRESS COUNTER TIMING CIRCUIT
LP
CP

FIG. 19 (a)

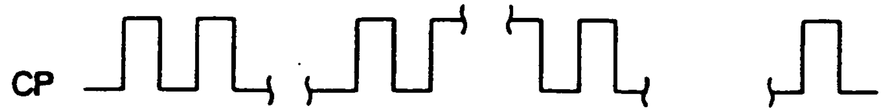


FIG. 19 (b)

FIG. 19 (c)

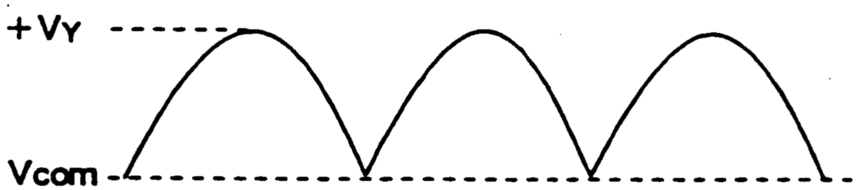


FIG. 19 (d)

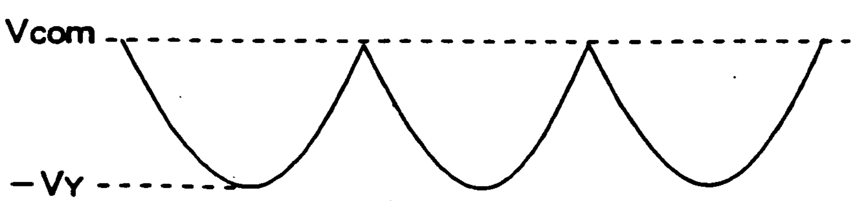
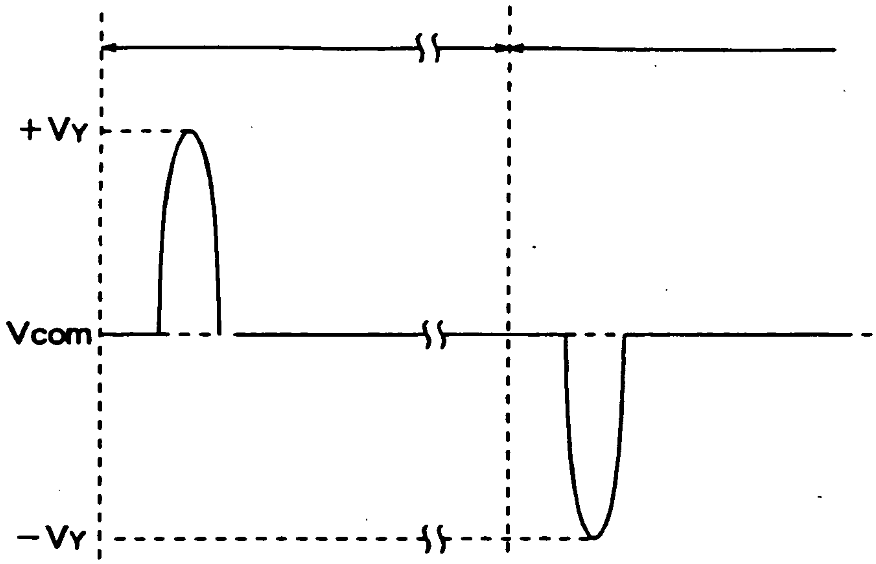
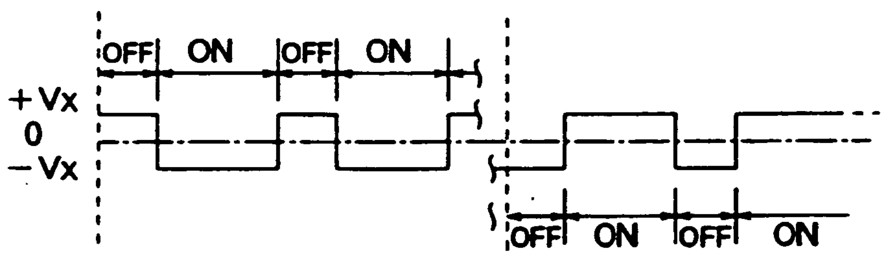


FIG. 20 (a)



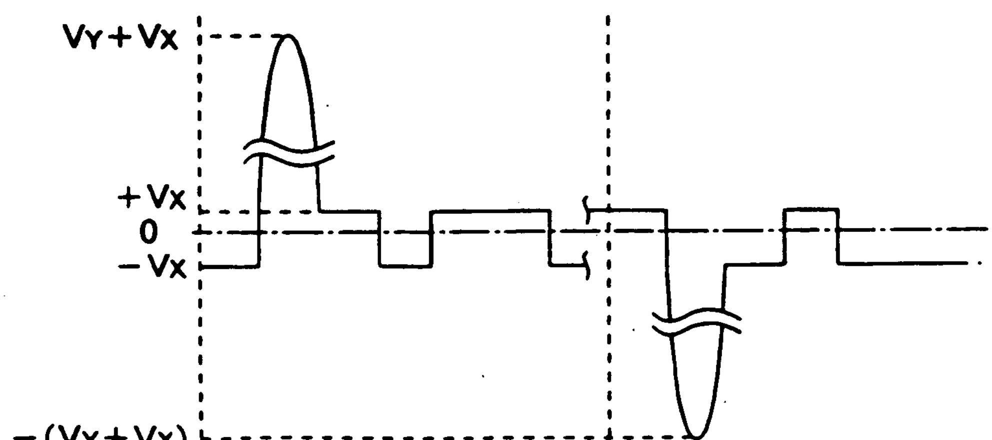
SCANNING SIGNAL POTENTIAL CONTROL TERMINAL

FIG. 20 (b)



DATA SIGNAL WAVEFORM

FIG. 20 (c)



LIQUID CRYSTAL APPLYING VOLTAGE WAVEFORM

FIG. 21

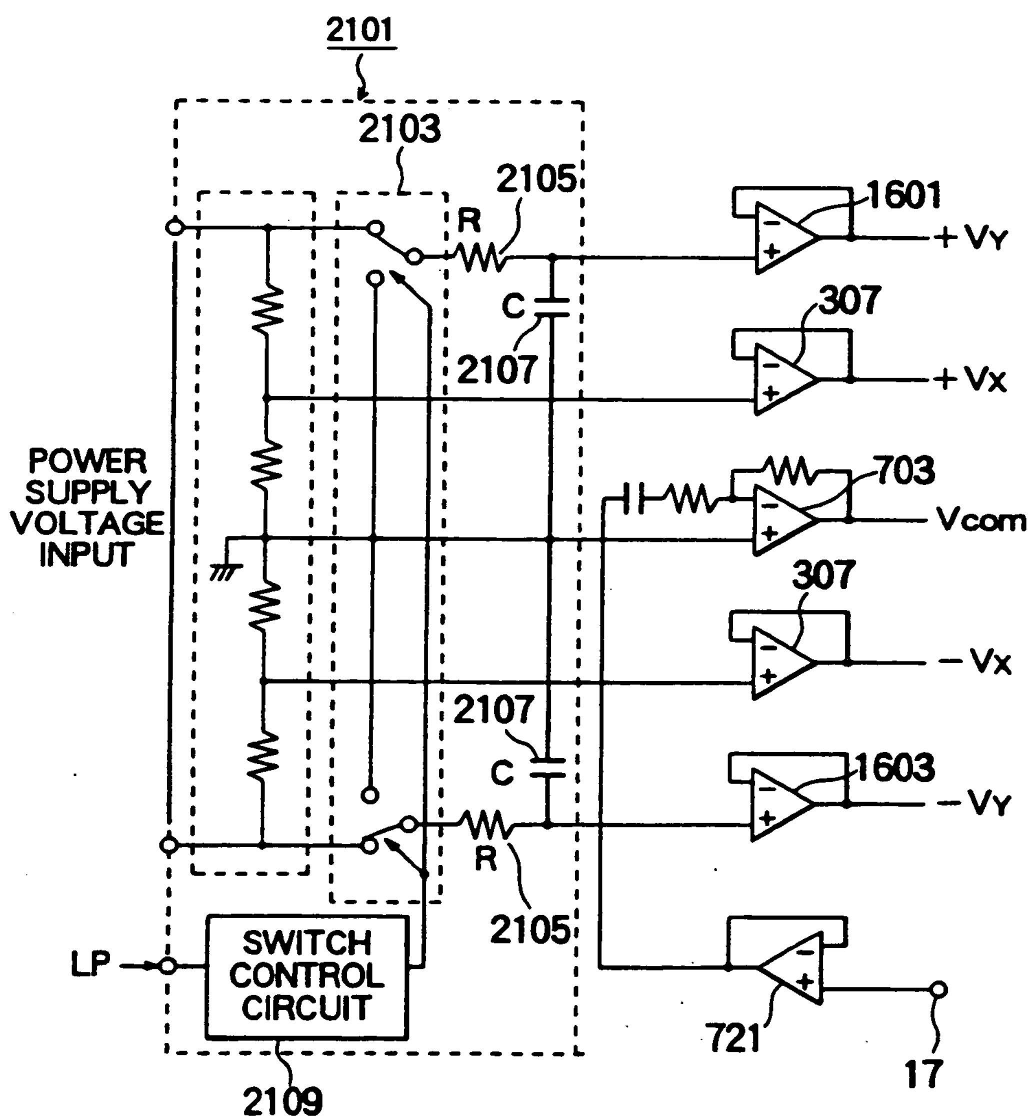

2101
2103
2105
R
1601
+VY
C
307
2107
+VX
POWER
SUPPLY
VOLTAGE
INPUT
703
Vcom
307
-VX
2107
C
1603
-VY
R
2105
LP
SWITCH
CONTROL
CIRCUIT
721
17
2109

FIG. 22 (a)

FIG. 22 (b)

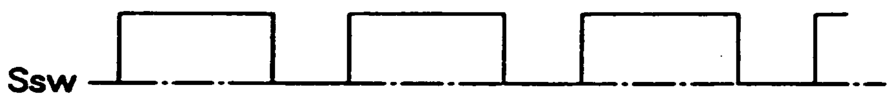


FIG. 22 (c)

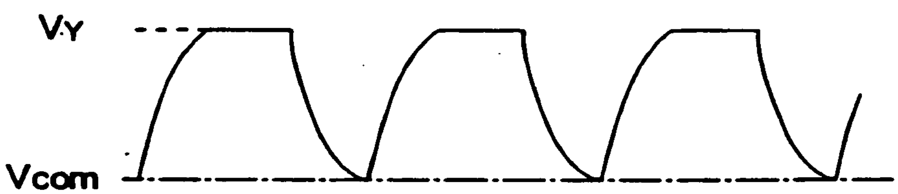


FIG. 22 (d)

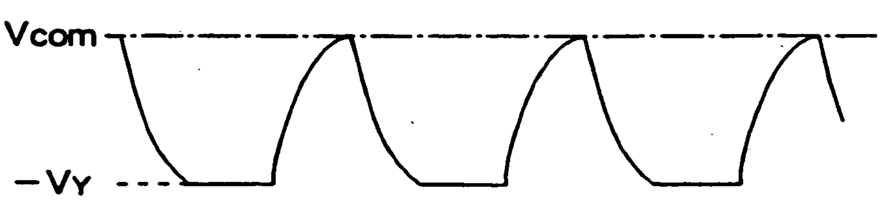
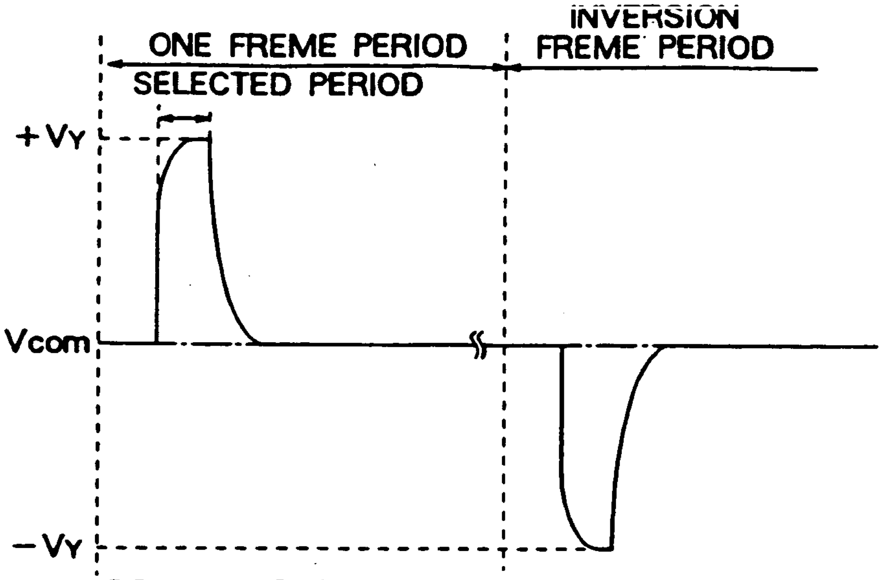
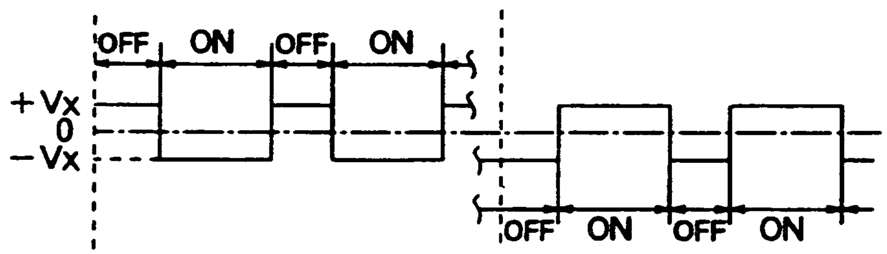


FIG. 23 (a)



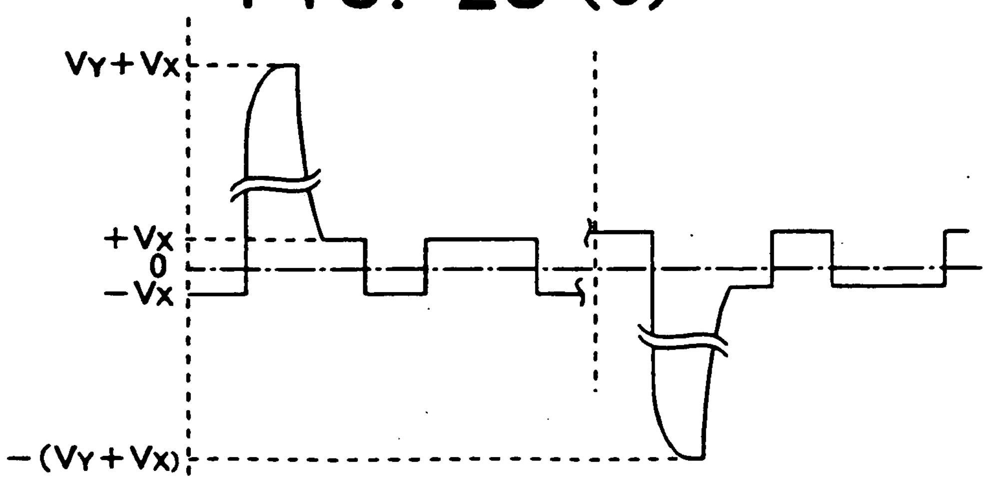
SCANNING SIGNAL WAVEFORM

FIG. 23 (b)



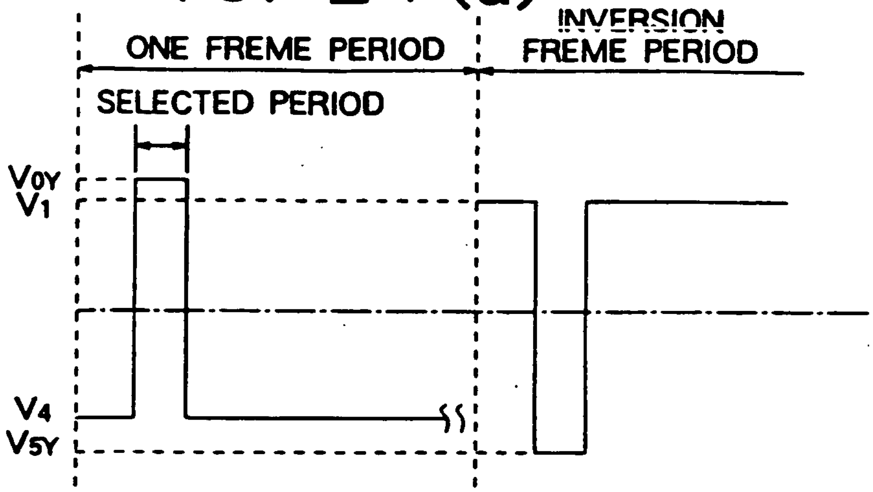
DATA SIGNAL WAVEFORM

FIG. 23 (c)



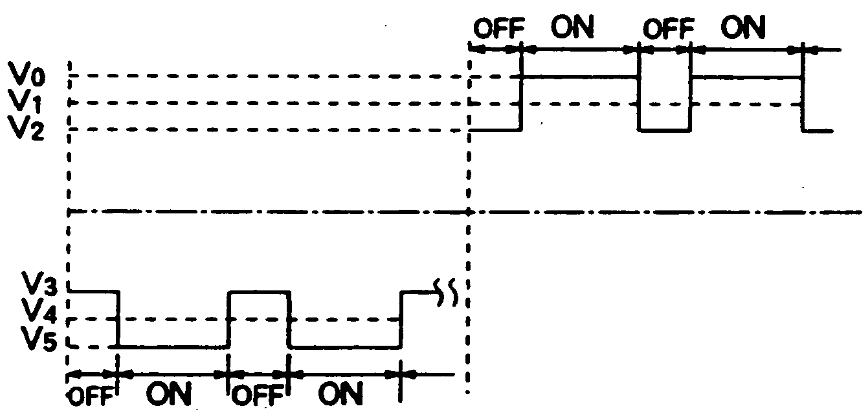
LIQUID CRYSTAL APPLYING VOLTAGE WAVEFORM

FIG. 24 (a)



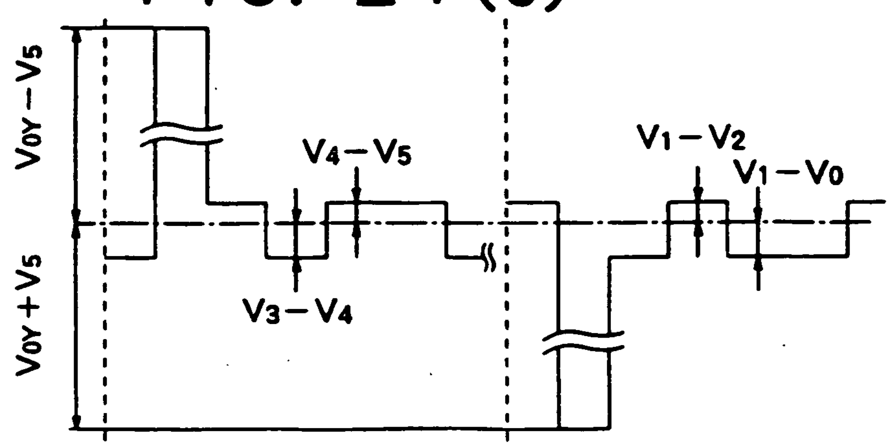
SCANNING SIGNAL WAVEFORM

FIG. 24 (b)



DATA SIGNAL WAVEFORM

FIG. 24 (c)



LIQUID CRYSTAL APPLYING VOLTAGE

FIG. 25

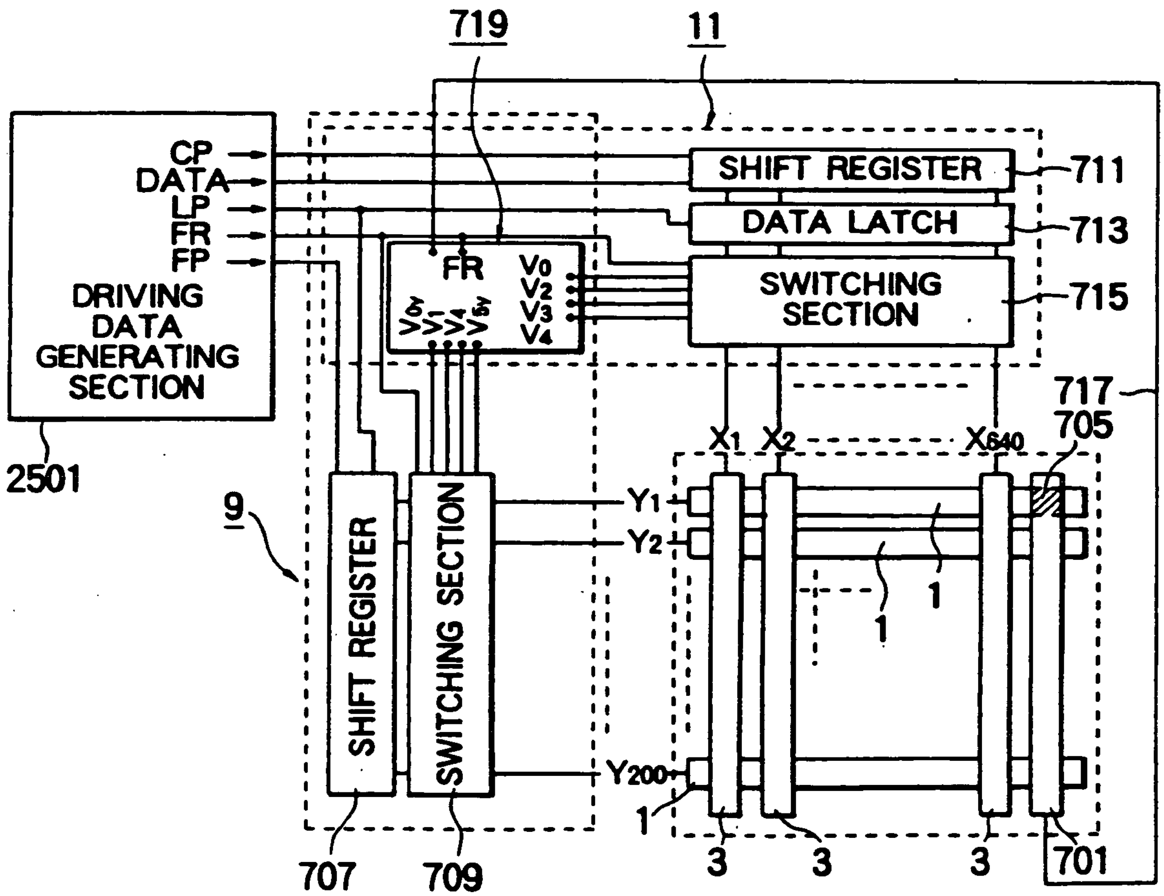

719
11
CP
DATA
LP
FR
FP
DRIVING DATA GENERATING SECTION
2501
SHIFT REGISTER
711
DATA LATCH
713
SWITCHING SECTION
715
FR
V0
V2
V3
V4
717
705
X1
X2
X640
Y1
Y2
Y200
9
SHIFT REGISTER
SWITCHING SECTION
1
3
701
707
709

FIG. 26 (a)

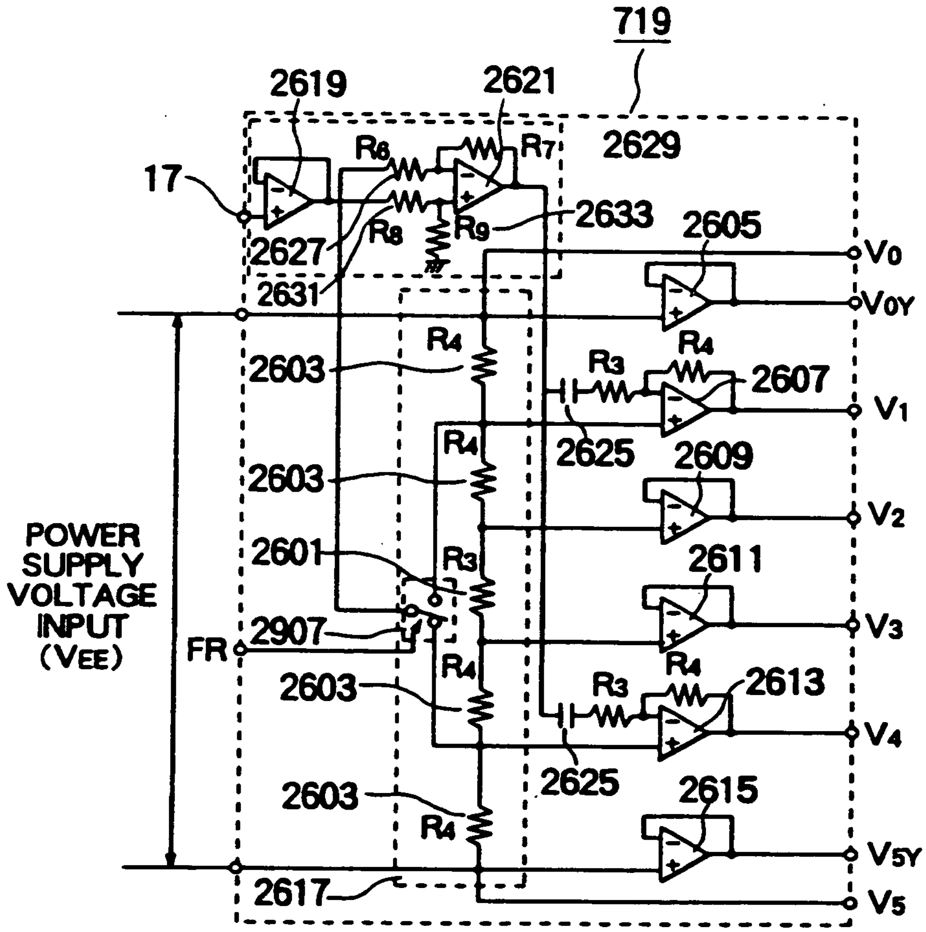


FIG. 26 (b)

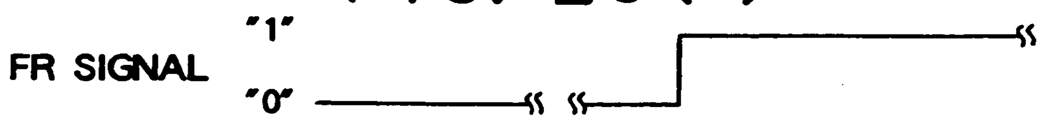


FIG. 26 (c)

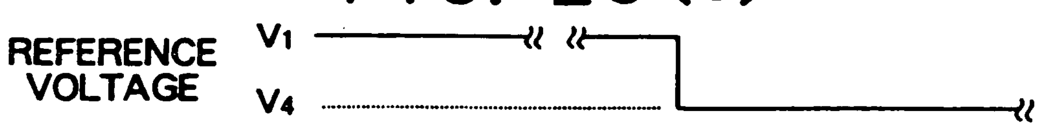


FIG. 26 (d)

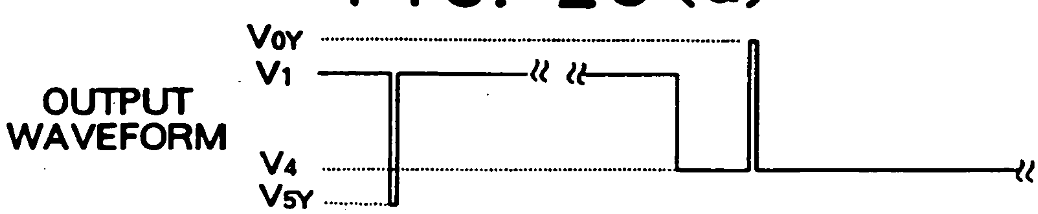
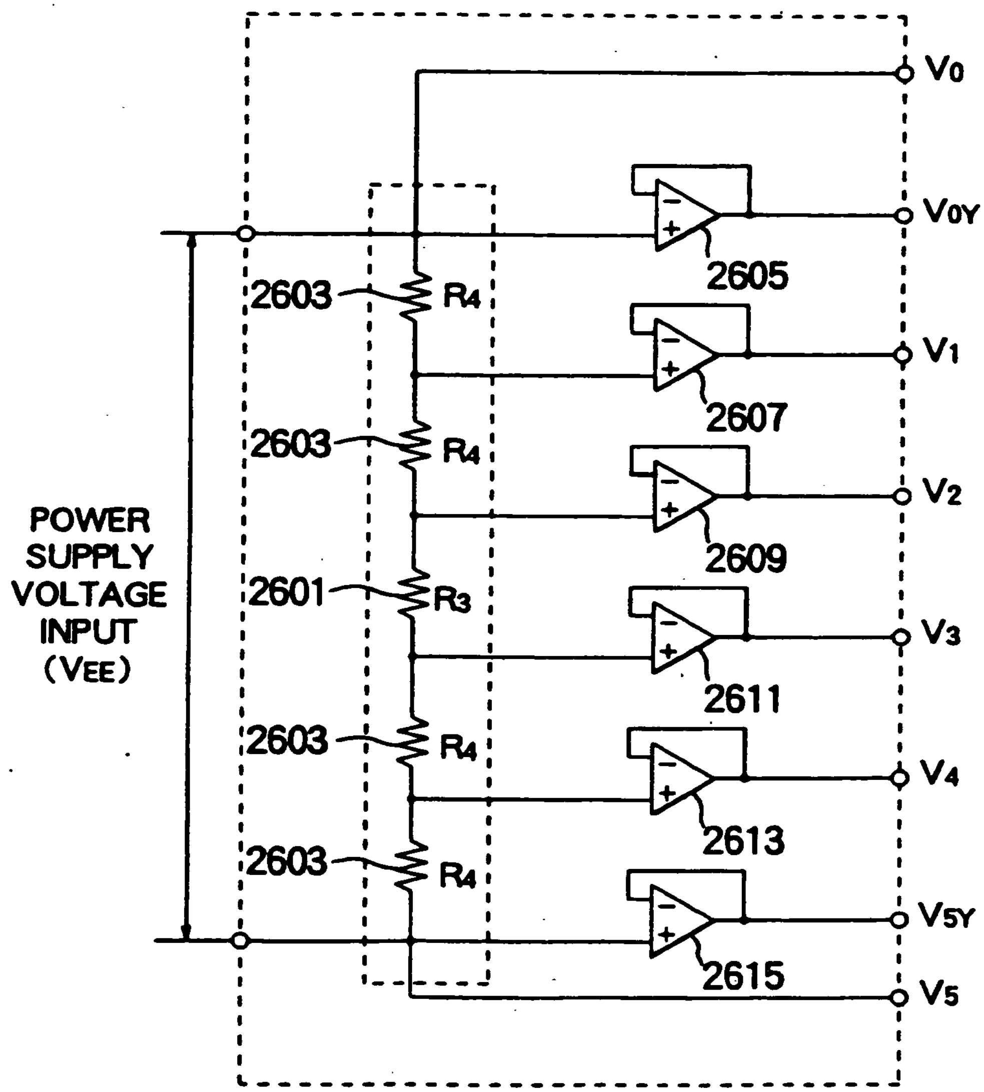


FIG. 27



V0
V0Y
2605
V1
2607
V2
2609
V3
2611
V4
2613
V5Y
2615
V5
2603
R4
2603
R4
2601
R3
2603
R4
2603
R4
POWER
SUPPLY
VOLTAGE
INPUT
(VEE)

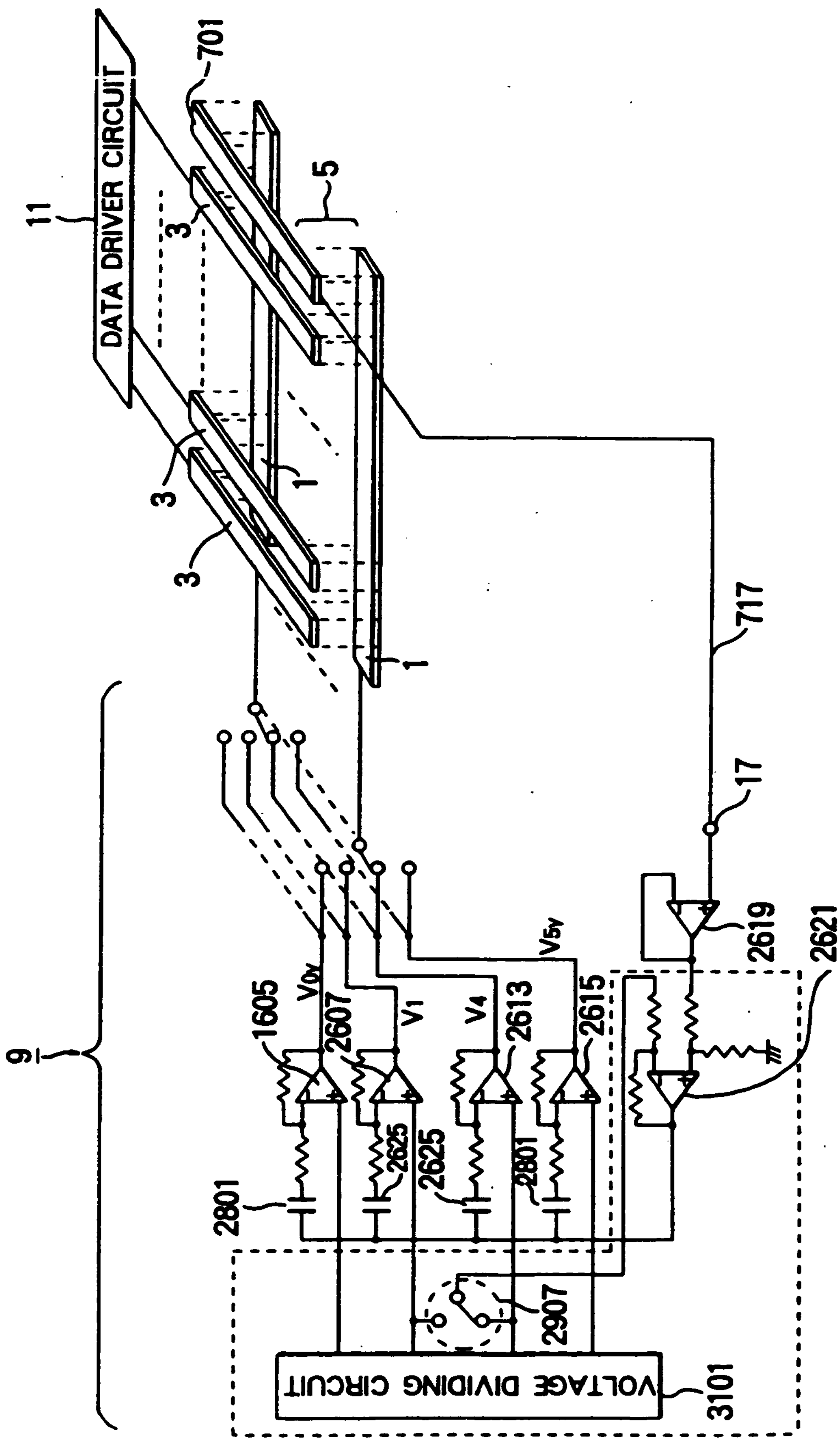

11
DATA DRIVER CIRCUIT
701
5
3
3
3
1
1
717
17
9
1605
V_{0V}
2607
V_1
V_4
2613
2615
V_{5V}
2619
2621
2625
2625
2801
2801
2907
VOLTAGE DIVIDING CIRCUIT
3101

FIG. 28

FIG. 29

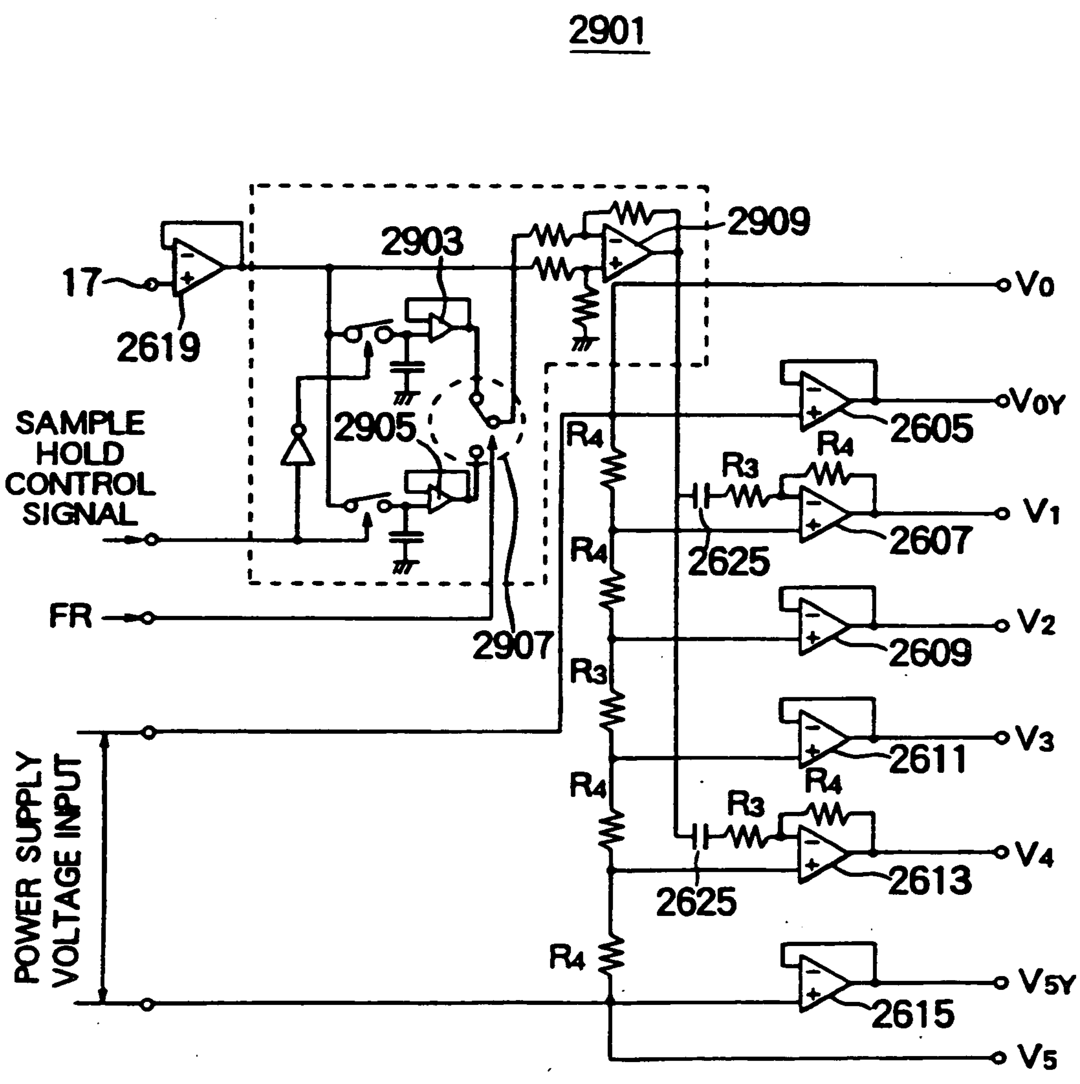

2901
2909
2903
17
2619
Vo
SAMPLE HOLD CONTROL SIGNAL
2905
R4
2605
VOY
R3
R4
V1
2625
2607
FR
2907
R4
V2
2609
R3
POWER SUPPLY VOLTAGE INPUT
V3
2611
R4
R3
R4
V4
2625
2613
R4
V5Y
2615
V5

FIG. 30 (a)

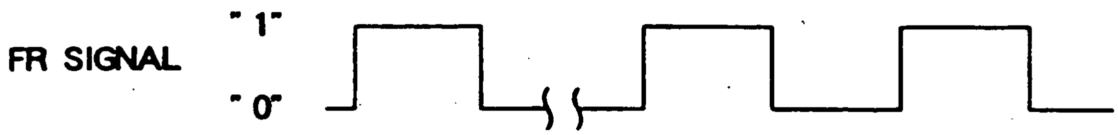


FIG. 30 (b)

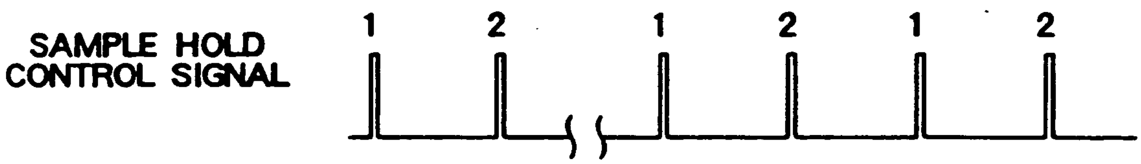


FIG. 30 (c)

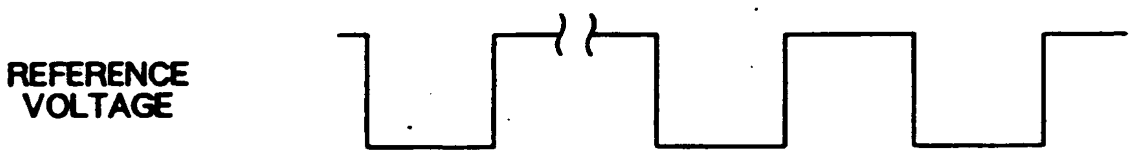


FIG. 30 (d)

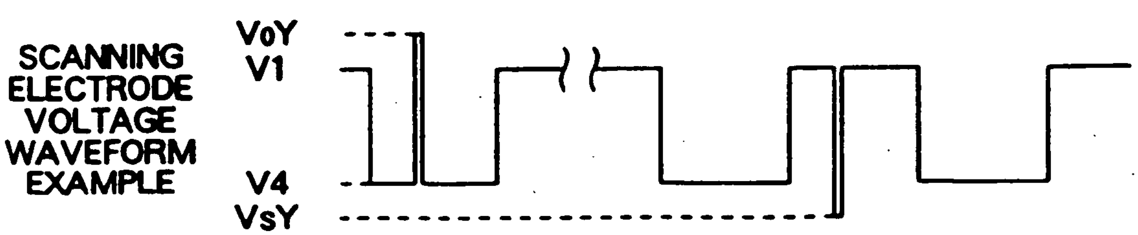


FIG. 31

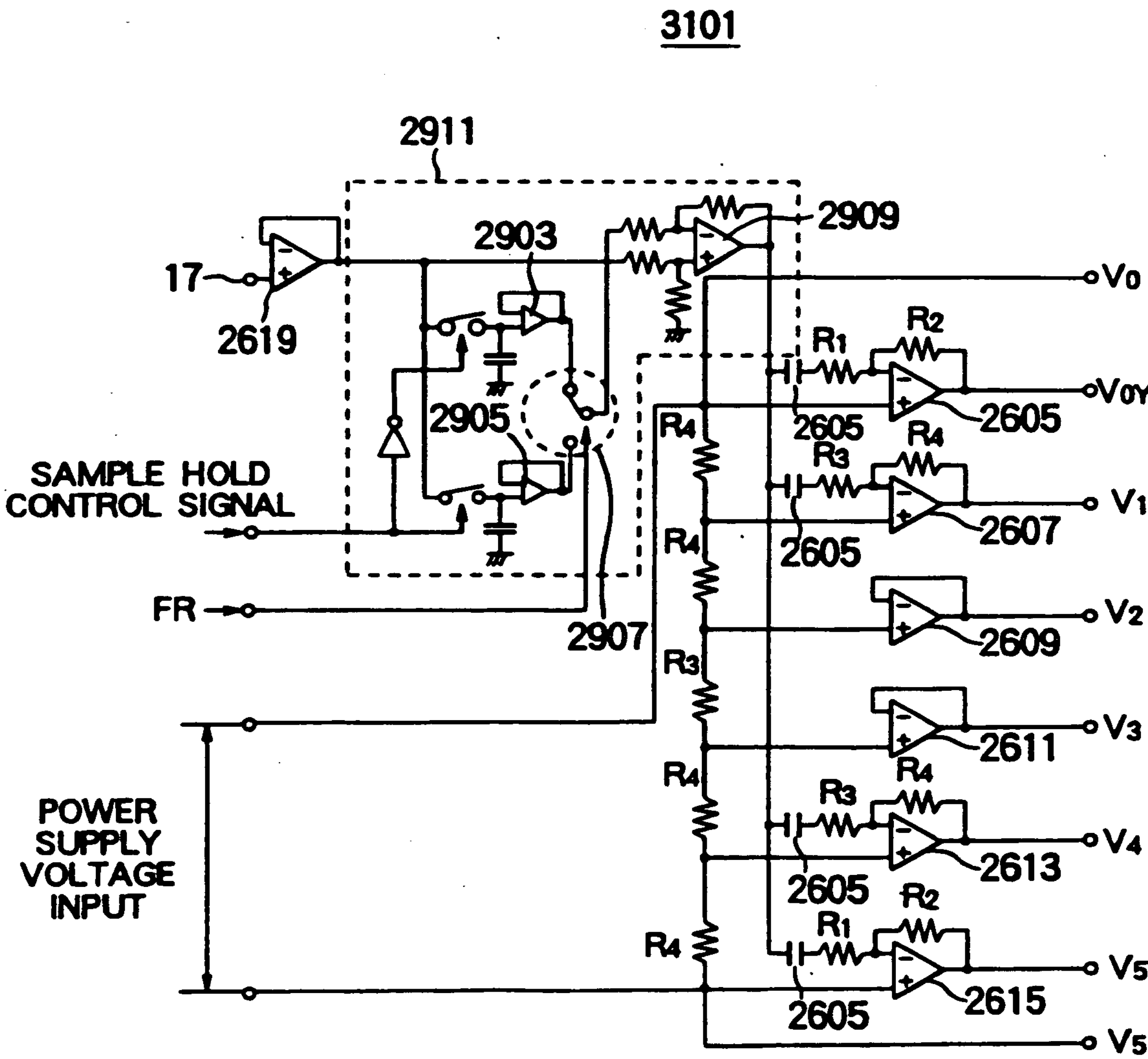
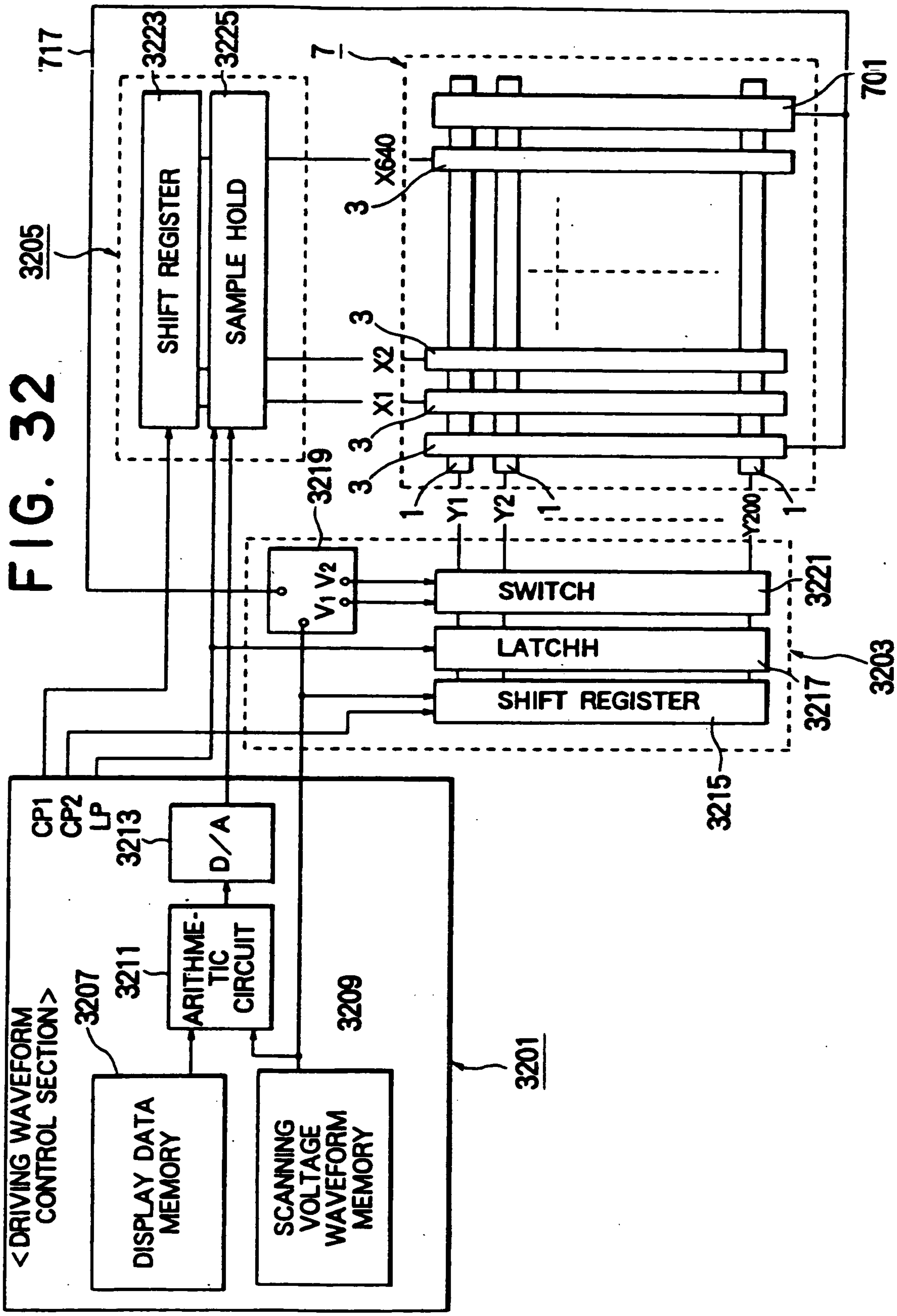
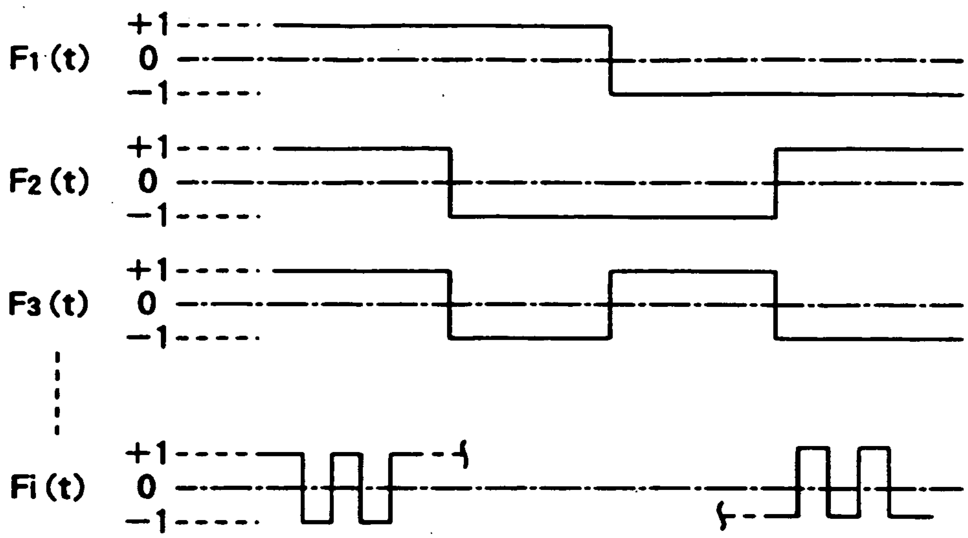

3101
2911
2909
2903
17
2619
Vo
R2
R1
V0Y
2905
2605
2605
R4
R3
R4
SAMPLE HOLD
CONTROL SIGNAL
V1
2607
R4
2605
FR
V2
2609
2907
R3
V3
2611
R4
R3
R4
POWER
SUPPLY
VOLTAGE
INPUT
V4
2613
2605
R2
R1
R4
V5Y
2615
2605
V5

FIG. 32



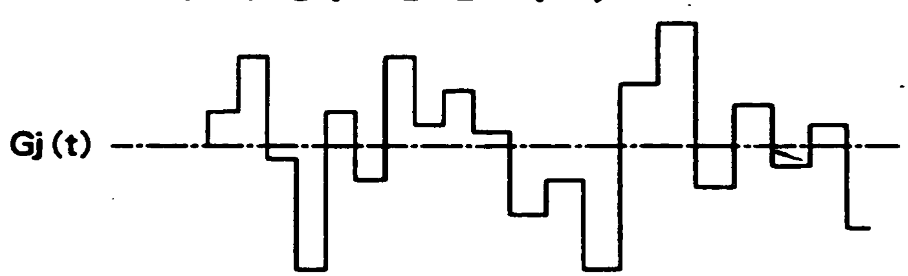
<DRIVING WAVEFORM CONTROL SECTION>
DISPLAY DATA MEMORY
SCANNING VOLTAGE WAVEFORM MEMORY
ARITHME-TIC CIRCUIT
D/A
CP1
CP2
LP
3201
3207
3209
3211
3213
SHIFT REGISTER
SAMPLE HOLD
3205
3223
3225
717
V1 V2
3219
SWITCH
LATCHH
SHIFT REGISTER
3203
3215
3217
3221
X1
X2
X640
Y1
Y2
Y200
1
3
7
701

FIG. 33 (a)



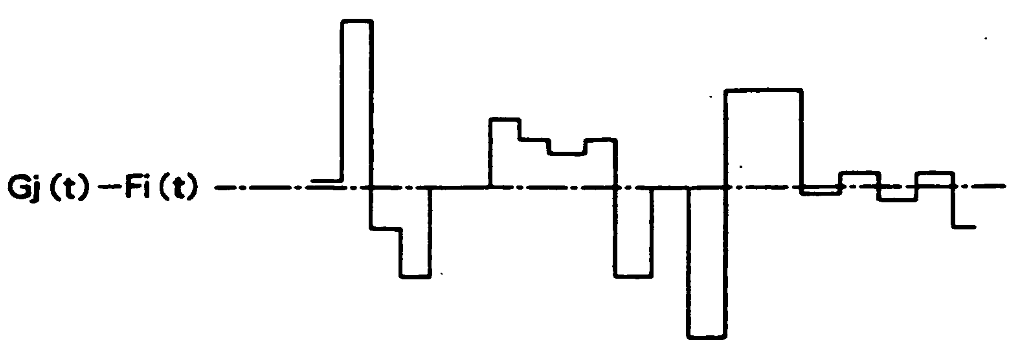
SCANNING WAVEFORM

FIG. 33 (b)



SIGNAL WAVEFORM

FIG. 33 (c)



LIQUID CRYSTAL APPLYING VOLTAGE WAVEFORM

FIG. 34

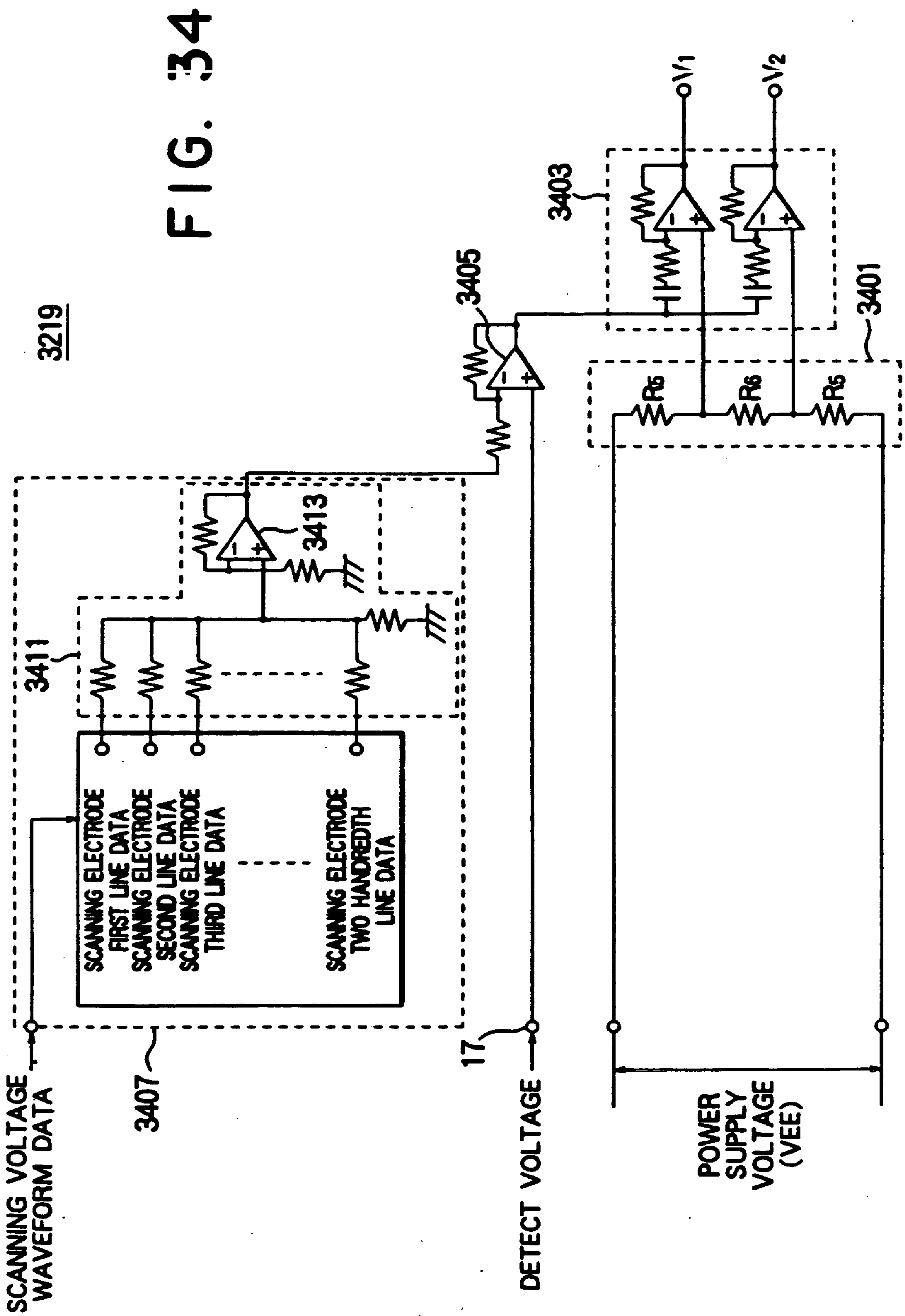

3219
3405
3403
V1
V2
3401
R5
R6
R5
3413
3411
SCANNING ELECTRODE FIRST LINE DATA
SCANNING ELECTRODE SECOND LINE DATA
SCANNING ELECTRODE THIRD LINE DATA
SCANNING ELECTRODE TWO HANDREDTH LINE DATA
SCANNING VOLTAGE WAVEFORM DATA
3407
17
DETECT VOLTAGE
POWER SUPPLY VOLTAGE (VEE)

FIG. 35

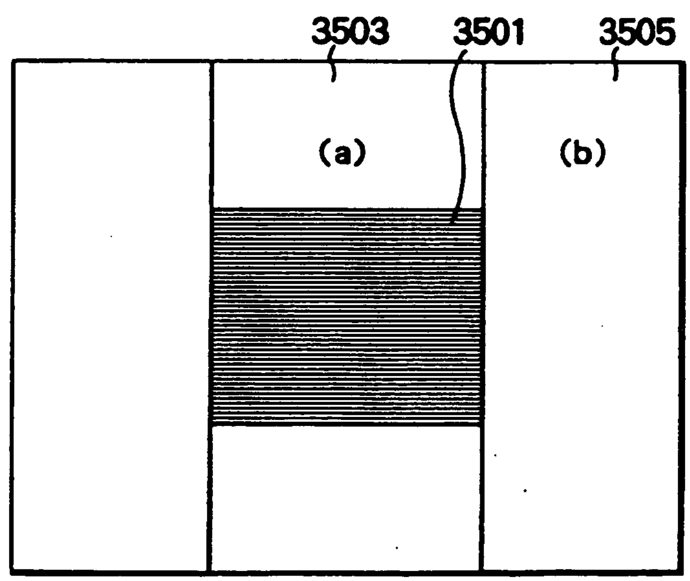


FIG. 36

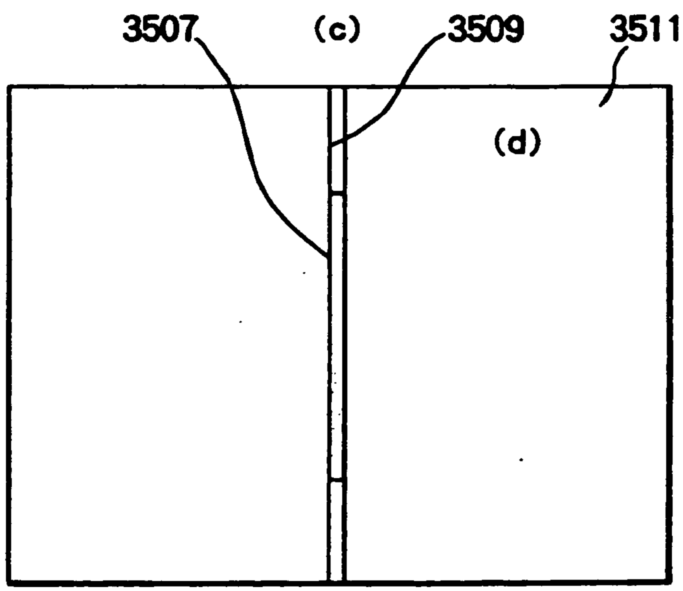


FIG. 37

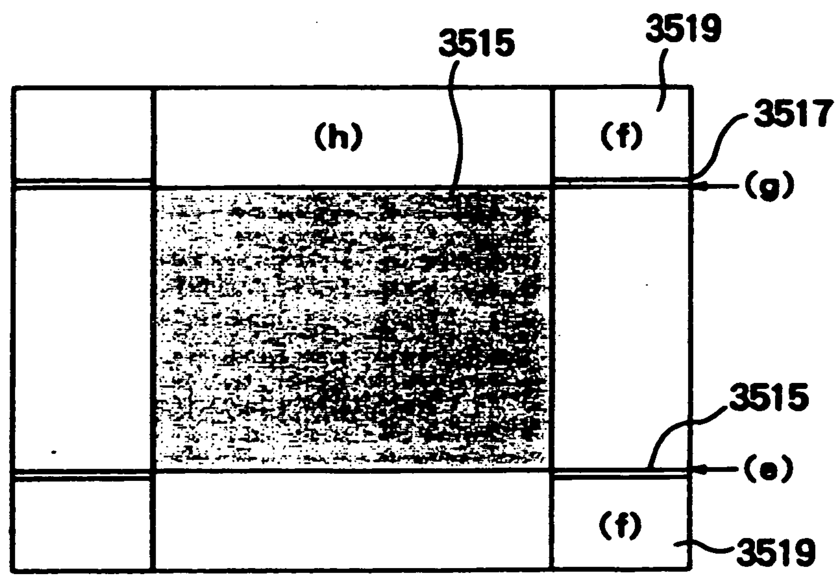


FIG. 38

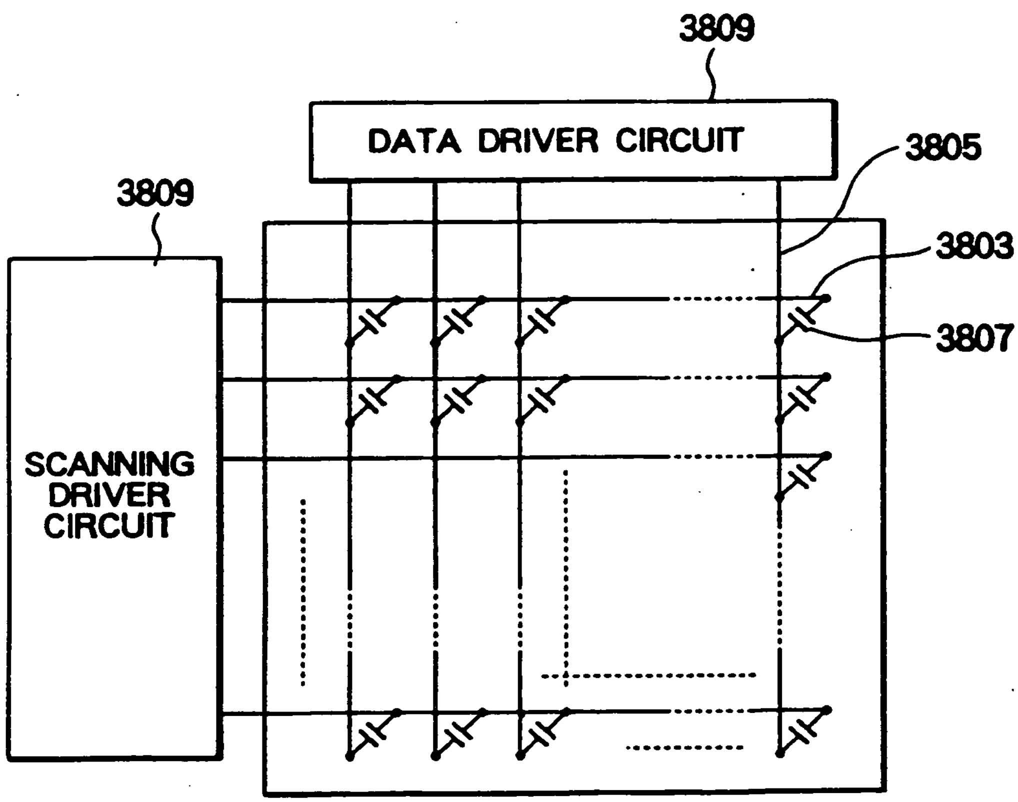

3809
DATA DRIVER CIRCUIT
3805
3809
3803
3807
SCANNING
DRIVER
CIRCUIT

FIG. 39 (a)

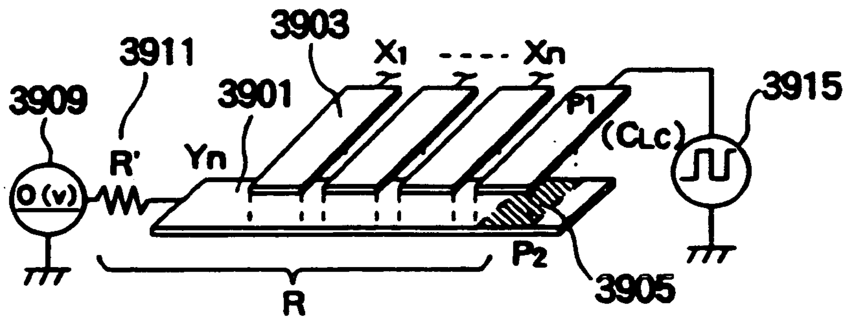


FIG. 39 (b)

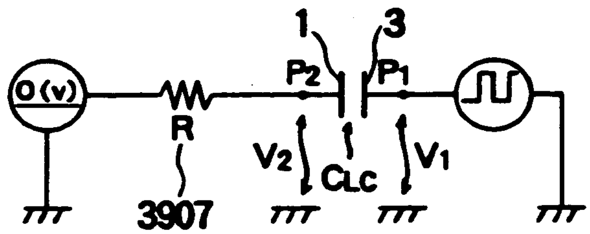


FIG. 39 (c)

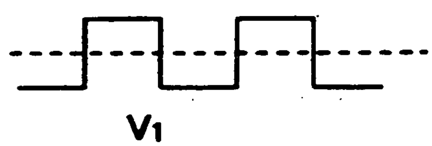


FIG. 39 (d)

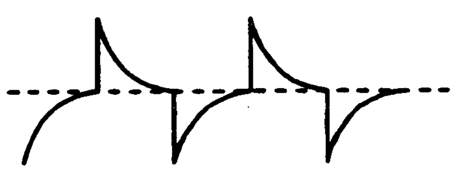


FIG. 39 (e)

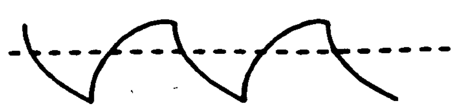
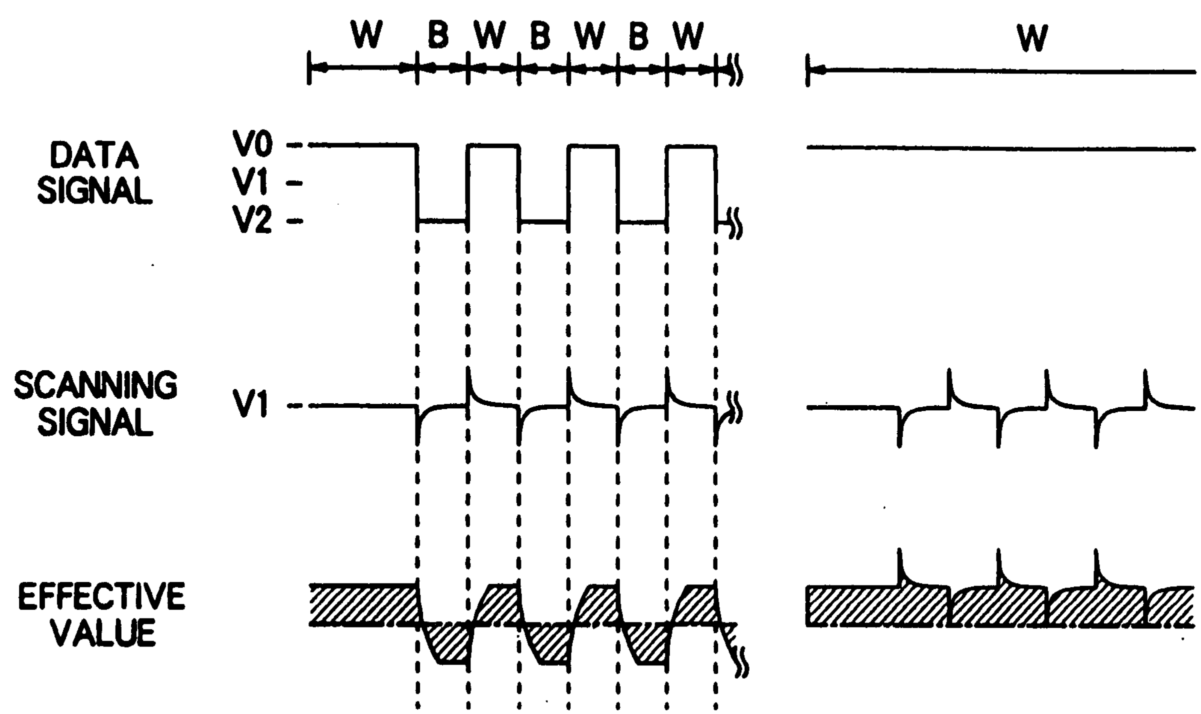


FIG. 40 (a) FIG. 40 (b)



WAVWFORM OF SCANNING NON-SELECTED PERIOD IN HORIZONTAL STRIP SHAPED DISPLAY PATTERN
(W : WHITE DISPLAY DATA,B : BLOCK DISPLAY DATA,
V0 : SELECTED SIGNAL POTENTIAL,
V1 : NON-SELECTED SCANNING POTENTIAL,
V2 : NON-SELECTED SIGNAL POTENTIAL)

WAVEFORM OF SCANNING NON−SELECTED PERIOD
AT POLARITY INVERSION TIME IN VERTICAL LINE DISPLAY
PATTERN AND BLOCK SHAPED DISPLAY
(W : WHITE DISPRAY DATA, B : BLACK DISPRAY DATA,
V0,V5 : SELECTED SIGNAL POTENTIAL,
V1,V4 : NON−SELECTED SCANNING POTENTIAL,
V2,V3 : NON−SELECTED SIGNAL POTENTIAL)

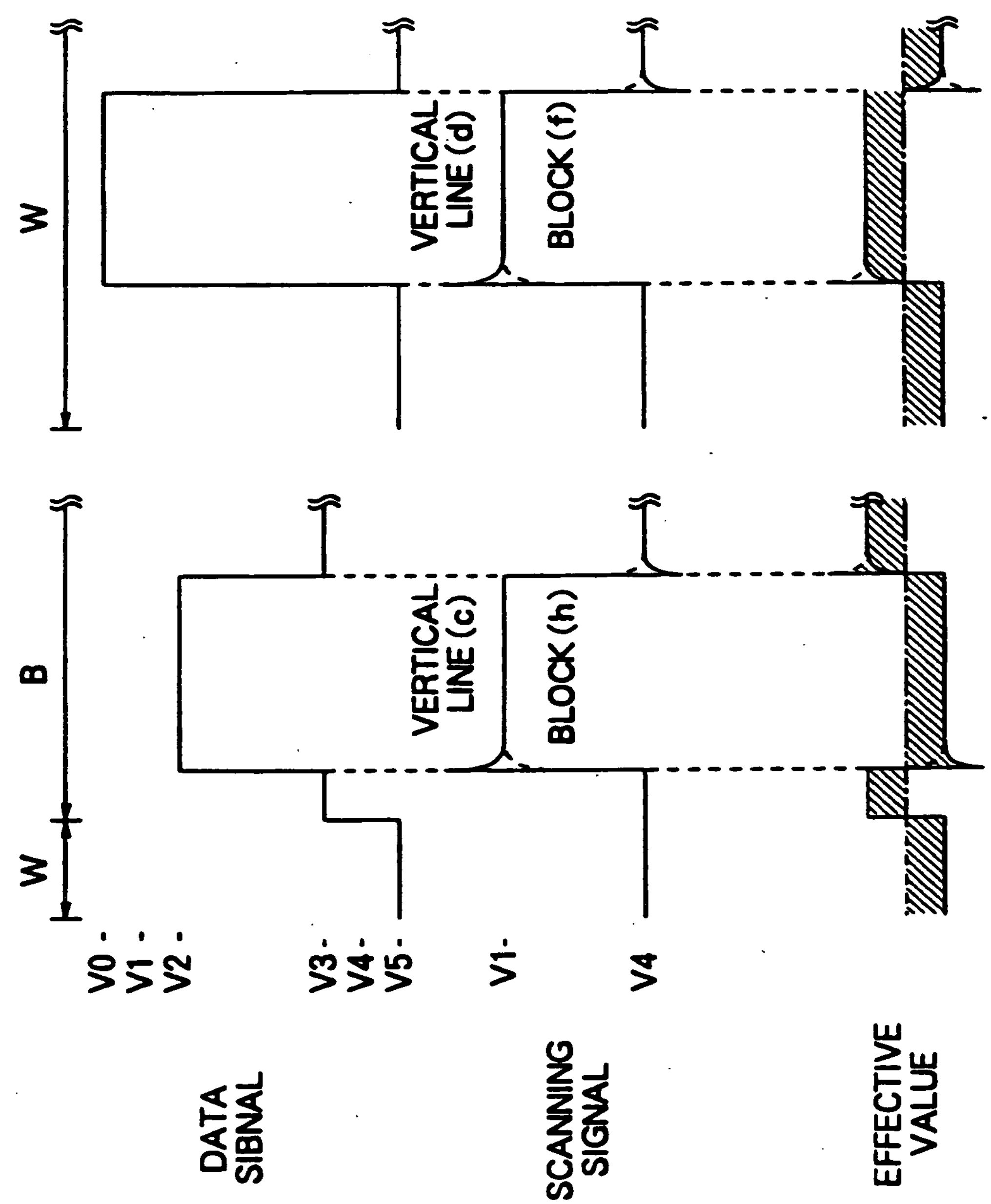


FIG. 41 (c)

FIG. 41 (d)

FIG. 42 (e)

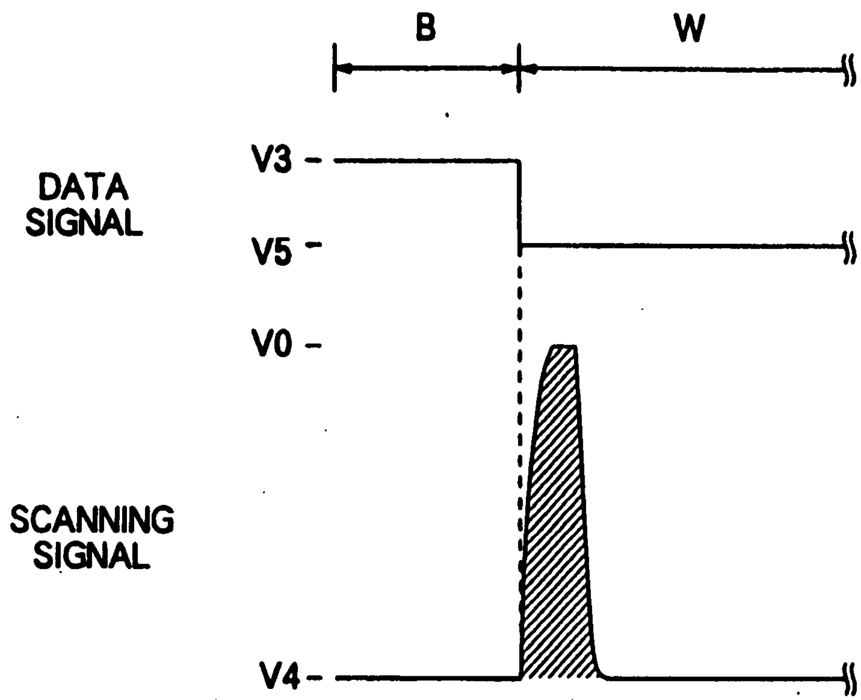
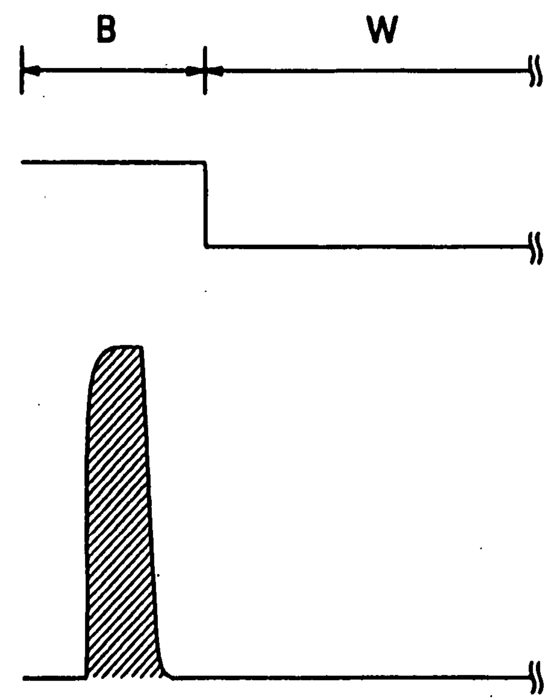


FIG. 42 (f)



WAVEFORM OF SCANNING SELECTED PULSE
IN BLOCK SHAPED DISPLAY PATTERN
(W : WHITE DISPLAYDATA,B : BLACK DISPLAY DATA,
V0 : SELECTED SCANNING POTENTIAL,
V4 : NON-SELECTED SCANNING POTENTIAL,
V3 : NON-SELECTED SIGNAL POTENTIAL,
V5 : SELECTED SIGNAL POTENTIAL)

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